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THE ELECTRIC POWER INDUSTRY IN LATIN AMERICA: PRESENT STATUS AND RECENT DEVELOPMENTS

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INTRODUCTION

The purpose of this paper is to describe and analyze the status of electricity production and consumption in the Latin American countries during the past few years, including the characteristics of its development.

Chapter I places Latin America's situation against the background of world power production, mainly with respect to electric power. In 1959 the average regional per capita production recorded at the power stations was 316 kWh, compared with the world average of 723 kWh. During the last ten years the figure for Latin America has increased at the annual cumulative rate of 6.4 per cent, while the corresponding increase for world production was 8.1 per cent. The increase in the relative importance of electric power compared with other forms of power is demonstrated by the fact that the region's share of world power consumption in 1937 was 15 per cent, in 1949 20 per cent, and at present is about 30 per cent. The chapter concludes by examining the factors that have led to this change.

Chapter II supplements and brings up to date the information on the relation between electricity consumption and general economic development contained in Energy in Latin America (E/CN.12/384/Rev.1),[1/] again confirming the close link between the two. However, it is explained that this interdependence does not imply that a country's level of income automatically determines its level of electricity consumption, which is influenced by such other factors as the structure of the production system, income distribution, climate, and so forth; special attention is drawn to the importance of the general process of innovation and technological progress in giving a dynamic character to the electrification process.

Chapter III examines advances in total and per capita production of electricity during the last 20 years in Latin America. Of Latin America's total production (62,600 kWh in 1959), the average contribution of the public services was 79.5 per cent, the rest being made up by self-suppliers;

1/ United Nations Publication, Sales N°.: 1956.II.G.2.

/the share

the share of the former group has increased during the last two decades. The contribution of water power to total power generated is given by country; for Latin America as a whole, this share amounted to 53 per cent for the whole sector, whereas for the public utilities alone the share was 61 per cent, with a trend towards a further increase.

The chapter continues with an evaluation of the amounts of fuel used in each country for the production of electricity, and reaches the conclusion that for the region as a whole over 17 per cent of the consumption of the commercial fuels specified is for this purpose, and that their imports weigh heavily on the balance of payments of some countries. The most commonly used fuels are the petroleum derivatives; next comes coal, but at a much lower level. The chapter concludes with an examination of the features of the installations required for production.

Chapter IV is devoted to a study of the development of installed capacity over the last two decades; in 1959 this amounted to 16 million kW for Latin America as a whole. The generating capacity of the public utilities, which represents about 76 per cent of this total, is about equally divided between thermal and hydroelectric plants. In 1959 about 70 per cent of the capacity under construction was of the hydroelectric type.

Over the years a marked trend has developed in the region towards the construction of plants with a higher potential and the use of units of higher capacity.

The average figure for plant utilization in 1959 was 3,860 hours, but the figure for the public utility hydraulic plants was over 4,780 hours.

Reserve capacity is usually inadequate, and except for a few systems the margin between installed potential and demand is dangerously narrow.

The first part of chapter V establishes the relationship between production and consumption of electricity. An average of 17.4 per cent of the regional power generated corresponded to losses, unrecorded consumption and consumption at the plants themselves. At peak hours the situation is even worse, and it is estimated that the losses to the consumer may be over 20 per cent. The second part of the chapter examines for each country the consumption of the various sectors - industrial, domestic, commercial, public lighting, transport and other, grouping them according to the way

/in which

in which the power is used, that is, as a factor of production or consumer good, and establishing correlations with other economic factors, on the basis of this classification.

Of the 40,900 million kWh of total net consumption by the public services in the region in 1959, 62 per cent represented urban non-industrial consumption, of which domestic consumption, the principal constituent, alone represented over 31 per cent. This level of domestic consumption constituted an average of about 150 kWh per urban inhabitant, and is twice as high as it was 10 years before.

Industrial and mining consumption in the region amounted to 27,500 million kWh, 56 per cent of which was provided by the public utilities and the remainder by self-supply. The annual growth rate of this consumption is increasing, but not as rapidly as that of the consumption of electricity as an end product. Consequently the proportion of total consumption represented by industrial and mining consumption dropped from 65 per cent in 1938 to 54.9 per cent in 1959.

To supplement the economic analysis of electricity at the national and regional level, chapter VI examines the electricity system as the basic functional unit and gives an account of some of the most representative systems in the region.

The following main conclusions can be drawn from this chapter:

(a) There is a wide variation in the consumption pattern of electricity from one country to another.

(b) There is a strong trend towards the interconnexion of systems in some countries in order to make better use of equipment and to supplement various hydrologic systems.

(c) In a number of countries there are systems operating on both 50 and 60 cycles; this lack of uniformity in frequency constitutes a serious economic problem in the integration of networks, which should be dealt with immediately in order to minimize future ill-effects.

(d) There is also a wide range of both high tension voltages and low utilization voltages; these should be standardized for obvious economic

/reasons, namely,

reasons, namely, reduction of spare-part inventories and standardization of industrial production in the region.

(e) In general the price of electricity has lagged far behind that of other prices, which has had a harmful effect on electrical development; in this field also there are certain discrepancies as between the various components of the energy sector.

Data with respect to the position in 1960 is fragmentary for most Latin American countries and completely lacking for some. Hence, only a general, provisional appreciation can be given at this point.

The increase in generating power in 1960 as compared with the previous year appears not to have exceeded 7 per cent for the area as a whole. This figure is very much below the average for the period 1955/59 when the annual cumulative rate of increase was 10.1 per cent. It also differs substantially from the increase in gross product - 3.7 per cent in the year 1959/60 - and in industrial expansion, which amounted to over 10 per cent compared with the previous year.

With the exception of Paraguay, Peru, El Salvador, Guatemala and Honduras, the growth in electricity generation seems to have slowed down, and in some countries a drop in absolute terms was registered. This was the case, for instance, in Chile where the decline was attributable to the disastrous earthquake in May 1960, which directly affected one-third of the population. Electricity production in Bolivia also declined, compared with the previous year.

Installed capacity during 1960 seems to have expanded by over 8 per cent in relation to the previous year, the main increases being registered in Brazil, Uruguay, Colombia, Venezuela and Peru. The effects of this increase in generating power will be felt more strongly in 1961 as a number of important works were only completed towards the end of 1960.

/Table A

Table A

LATIN AMERICA: ESTIMATE OF ELECTRICITY GENERATED BY PUBLIC UTILITIES - 1960

(Millions of kWh)

Argentina	8 000
Brazil	21 000
Chile	2 340
Colombia	2 900
Peru	1 150
Uruguay	1 250
Mexico	8 330
Rest of Latin America	18 000
Total	53 000

Table A shows the 1960 figures for electricity generation and capacity - in detail for those countries where they are based on fairly accurate data and as a whole for the rest of Latin America.

In the same year self-supply may have amounted to about 12.5 to 13.5 million kWh, so that the total figure for electricity generation was certainly in the vicinity of 66 thousand million.

/Chapter I

Chapter I

POWER CONSUMPTION IN LATIN AMERICA AND IN THE WORLD

1. Total power consumption

Consumption of power obtained from different sources must be expressed in terms of a common unit. That adopted in the present study is one ton of normal crude petroleum (10,700 kilocalories/kilogramme), because the calorific power of this fuel is more uniform than that of other natural fuels and because it is the commonest form of energy in Latin America (see Energy in Latin America, United Nations publication, Sales No.: 1957.II.G.2). In the present chapter, the conversion of hydroelectricity to petroleum equivalent is based on average world yields of thermoelectric power stations. For the years 1937, 1949 and 1955-59 respectively, 0.46., 0.40 and 0.38 kg of petroleum were taken as equivalent to 1,000 kWh.

Gross consumption of commercial power,[1/] shown for 1959 by areas in table 1, bears witness to the low level of power consumption at the present time in the Latin American countries, which in the aggregate account for only 3 per cent of world consumption. The region's average per capita supply of power is comparatively small, in line with its level of income, and in 1959 was the equivalent of a little over 420 kilogrammes of petroleum, or 45 per cent of average world consumption (940 kilogrammes). Although there is still a wide gap between the Latin American figure and the corresponding figures of 1,800 kilogrammes for Europe and 5,300 kilogrammes for the United States, progress in this field is more rapid in Latin America, and consequently the region's relative position has improved

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1/ Petroleum (including natural gas), coal and electricity. In general terms, gross consumption is identical with apparent consumption: output of primary energy sources plus imports and minus reserves kept in stock. In the case of liquid fuels, however, instead of production at the well, the refinery output of the various derivatives is taken. Vegetable and other similar fuels are excluded because they are very difficult to assess exactly. Nevertheless, consumption of these in Latin America amounts to about 25 million tons of petroleum equivalent, as will be seen later.

/from the

from the 1.8 per cent of total consumption which it represented twenty years ago, to 2.5 per cent ten years ago and 3.0 per cent in 1959 (see table 2). A similar process may be noted in the other group of under-developed countries and in Eastern Europe. The annual rate of growth of per capita consumption is also higher in Latin America than in the world as a whole, the disparity having become more marked during the last decade, when annual rates of 5.0 per cent and 3.3 per cent, respectively, were registered (see table 3). This increase is still more significant in view of the high rate of population growth which characterizes the region. It is possible that the real expansion in Latin America, as in the other group of under-developed countries which also has a more rapid growth rate than the average, may be somewhat less than the figures would suggest, since in these countries statistical coverage is progressively improving and, furthermore, non-commercial fuels (wood, industrial residues, etc.) are being rapidly ousted by substitutes.

(a) Non-commercial fuels

For the purpose of evaluating the importance of such fuels - whose total can only be estimated, for want of country statistics -, they may be taken to have represented about 28 per cent of Latin America's total consumption of power in 1955, as can be seen in table 4. If fuels of this type were taken into account, average per capita power consumption in the region would rise to 53 per cent of the world average, instead of the 45 per cent indicated above for commercial power. Their importance tends to decline as the economic development process advances, since in the above-mentioned year the figures in question, which were about 40 per cent and over in the less developed countries, fell as low as 5-10 per cent in Europe and 3 per cent in the United States. To judge from the data to hand, in Latin America, prior to the Second World War, non-commercial fuels may be estimated to have accounted for something like 50 per cent of total energy consumption. Broadly speaking, and in so far as the scanty data available permit, the absolute volume of consumption of vegetable fuels can be seen to remain stationary or to pursue a downward trend interrupted only in abnormal periods (during an economic depression, in time of war, etc.). Hence, their gradual loss of relative significance.

/Table 1

Table 1

WORLD CONSUMPTION OF COMMERCIAL POWER, 1959

(In terms of petroleum equivalent)

Region or country	Total (millions of tons)	Per capita (kilogrammes)
Latin America	83	422
Western Europe	556	1 717
Eastern Europe	595	1 930
United States	937	5 242
Other developed countries a/	225	1 620
Rest of the world	352	199
World total	2 748	942

Source: For Latin America, direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 4.

a/ Australia, Canada, Japan, New Zealand and the Union of South Africa.

/Table 2

Table 2

CONSUMPTION OF COMMERCIAL POWER AS A PERCENTAGE OF WORLD CONSUMPTION

Region or country	1937	1949	1955	1959
Latin America	1.8	2.5	2.8	3.0
Western Europe	30.4	23.7	23.5	20.2
Eastern Europe	16.2	20.0	19.9	21.7
United States	39.5	41.2	39.0	34.1
Other developed countries a/	7.9	8.0	8.2	8.2
Rest of the world	4.2	4.6	6.6	12.8

Sources: For Latin America, direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 3.

a/ See note to table 1.

/Table 3

Table 3

ANNUAL RATES OF GROWTH OF WORLD GROSS CONSUMPTION OF COMMERCIAL POWER

(Percentages)

Region or country	Period	Total consumption	Per capita consumption	Share of hydrocarbons in total consumption
World total	1937-59	3.7	2.3	2.7
	1949-59	5.5	3.3	2.6
Latin America	1937-59	6.2	3.9	1.4
	1949-59	7.6	5.0	0.5
Western Europe	1937-59	1.8	1.2	6.7
	1949-59	3.8	3.1	10.4
Eastern Europe	1937-59	5.1	4.4	1.7
	1949-59	6.3	5.1	4.6
United States	1937-59	3.0	1.5	2.7
	1949-59	3.5	1.7	2.7
Other developed countries	1937-59	3.8	2.4	4.3
	1949-59	5.8	4.1	7.2
Rest of the world	1937-59	8.9	7.1	-1.3
	1949-59	16.9	14.1	-7.5

/Table 4

Table 4

WORLD CONSUMPTION OF POWER, 1955

(In terms of petroleum equivalent)

Region or country	Total power		Commercial power		Commercial power as a percentage of total power consumption (3)/(1)
	Total gross consumption (millions of tons)	Per capita consumption (kilogrammes)	Total gross consumption (millions of tons)	Per capita consumption (kilogrammes)	
	(1)	(2)	(3)	(4)	(5)
Latin America	88	490	63	353	71.6
Western Europe	556	1 780	524	1 678	94.4
Eastern Europe	495	1 700	444	1 523	89.8
United States	893	5 410	870	5 274	97.5
Other developed countries a/	200	1 530	182	1 391	91.0
Rest of the world	245	153	148	92	60.4
World total	2 477	924	2 231	832	90.1

Source: ECLA, on the basis of miscellaneous data.

a/ It was assumed that aggregate consumption of non-commercial fuels was approximately the same in 1949 (see United Nations, Statistical Papers, Ser. J, No. 1). The error involved in this hypothesis also affects the group listed as "Rest of the world", because the figure for this is calculated by subtraction of the sum of the other regions and countries from the values for the world as a whole.

(b) Contribution of hydrocarbons

To revert to the so-called commercial sources of power it is interesting to note the importance acquired in Latin America by petroleum and its derivatives, which meet approximately 77 per cent of requirements, a higher proportion than in the other major groups of countries (see table 5). This level had already been practically reached in 1955, and differs little from that attained in 1949, after a sharp upswing in the previous decade; whence it may be inferred that the maximum level of participation of such fuels has been reached. Everywhere in the world (except in some non-Latin American under-developed countries), an upward trend is observable in the share of hydrocarbons in aggregate sources of power, mainly because they are superseding coal.

(c) Contribution of hydroelectric energy

The contribution of hydroelectric resources is increasing in Latin America, in line with the world trend (see again table 5). In 1959 it reached about 15 per cent, after having hovered around 14 per cent during the two preceding decades. Such a proportion is high in comparison with the percentages recorded in other countries of the world, and is exceeded only in those which are, like Latin America, generously endowed with this resource (Canada, New Zealand, etc.). In most of the Latin American countries there is plenty of hydraulic potential,[2/] which constitutes the second most important source of energy supplies.

2. Electric power

With respect to the production of electricity,[3/] a comparison between Latin America and the groups of countries previously selected shows a striking similarity between their relative positions (see table 6). In 1959 the region attained a per capita production of a little over 315 kWh, representing 44 per cent of the world average of about 720 kWh. On the

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2/ See Hydroelectric resources in Latin America: their measurement and utilization (ST/ECLA/CONF.7/L.3.0).

3/ Including both production for public utility purposes and privately produced electricity generated by mines, industrial plants, etc., for their own use. Statistics usually cover the plants' own consumption.

Table 5

SHARE OF HYDROCARBONS AND HYDRO POWER IN GROSS CONSUMPTION OF COMMERCIAL POWER

(Percentages)

Region or country	Hydrocarbons				Hydro power			
	1937	1949	1955	1959	1937	1949	1955	1959
Latina America	57.3	73.1	77.1	78.6	13.5	13.6	12.7	14.5
Western Europe	6.4	10.0	26.8	22.6	7.6	9.7	11.6	13.7
Eastern Europe	16.0	14.9	23.4	22.8	1.6	1.4	2.3	3.4
United States	39.2	54.0	70.5	68.6	4.1	5.4	5.3	5.8
Other developed countries a/	12.6	15.9	32.0	29.3	24.0	26.6	27.4	28.9
Rest of the world	22.9	37.9	17.3	21.1	5.3	7.0	3.0	3.7
World total	23.1	32.4	41.7	41.1	6.6	7.5	8.0	8.7

Source: For Latin America: ECLA, on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 3.

a/ See note to table 1.

/Table 6

Table 6

WORLD PRODUCTION OF ELECTRICITY, 1959

Region or country	Total (millions of MWh)	Per capita (kWh)
Latin America	62	316
Western Europe	500	1 554
Eastern Europe	367	1 192
United States	795	4 489
Other developed countries a/	253	1 836
Rest of the world	104	60
World total	2 081	723

Source: For Latin America: ECLA, on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, No.3.

a/ See note to table 1.

other hand, there is cause for concern in the fact that the region is losing ground in relation to other countries. Its total production of 62,600 million kWh constituted 3.0 per cent of the world total, a proportion which had already been nearly reached in 1937 and was lower than the 3.2 per cent attained in 1949 (see table 7). The 6.6 per cent growth rate of per capita production during the last ten years (as against a world average of 8.1 per cent) was the lowest registered among the groups of countries under consideration, no doubt largely as a result of the region's rate of population growth which is one of the highest in the world.

In reality, the increase in production in Latin America has not been very low in absolute terms (9 per cent in 1949-59), despite the stagnation of economic development in many of the countries of the region during the last few years. Attention must be drawn, however, to the wide margin for expansion existing in this connexion in view of the fact that such highly electrified countries as the United States showed annual rates of increase of approximately 10 per cent (see table 8).

As a result of the large share of such countries in world production, the degree of electrification is rising rapidly all over the world.

(a) Consumption of electricity in relation to other forms of energy

So great is the influence of electricity at the present time that the idea of a human activity in which it does not play a preponderant role is almost inconceivable. Industrial development, widespread mechanization and urban progress demand plentiful supplies of electricity. The share of electricity in world consumption of commercial power may be estimated to have reached over 29 per cent in 1959, whereas in 1937 it was 15 per cent

/ Table 7

Table 7

PRODUCTION OF ELECTRIC POWER AS A PERCENTAGE OF WORLD PRODUCTION

Region or country	1937	1949	1955	1959
Latin America	2.7	3.3	2.8	3.8
Western Europe	34.0	28.0	25.2	24.0
Eastern Europe	14.7	14.5	15.8	17.6
United States	28.7	37.0	41.1	38.3
Other developed countries a/	16.6	14.0	11.9	12.2
Rest of the world	3.3	3.2	3.2	5.0

Source: For Latin America: ECLA? on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, No. 3.

/Table 8

Table 8

AVERAGE ANNUAL RATES OF GROWTH OF TOTAL WORLD GENERATION OF ELECTRIC POWER

(Percentages)

Region or country	Period	Total generation	Per capita generation	Percentage share of thermo electricity in total generation
World total	1937-59	7.5	6.2	0.8a/
	1949-59	10.3	8.1	1.2b/
Latin America	1937-59	8.1	5.7	-
	1949-59	9.1	6.4	-
Western Europe	1937-59	5.9	5.4	0.2
	1949-59	8.6	7.8	0.03
Eastern Europe	1937-59	8.5	7.8	-0.28
	1949-59	12.4	11.1	-0.81
United States	1937-59	9.0	7.5	1.09
	1949-59	10.6	8.7	1.47
Other developed countries a/	1937-59	6.1	4.6	0.8a/
	1949-59	8.7	7.0	3.5b/
Rest of the world	1937-59	9.7	8.0	1.5a/
	1949-59	15.3	12.6	4.8b/

Sources: For Latin America: ECLA, on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 3.

a/ 1937-58.
b/ 1949-58.

/and in

and in 1949 20 per cent.4/

Coefficients of electrification by areas demonstrate the steady advance of electricity as the form of energy to which preference is given throughout the world (see table 9). The statistics for Latin America are high in comparison to the figures for other groups of countries, principally because of the high proportion of non-commercial fuels which help to meet their energy requirements but are excluded from the present comparison.5/ On the other hand, while the annual world growth rate of the electrification factor has been about 6 per cent during the last ten years, in Latin America it has increased only by some 3.0 per cent and in the other under-developed countries has remained stationary.

This is the result of the limited supply of electricity generally available in these areas. As electricity is a highly-developed form of

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4/ The "degree of electrification" may be defined as follows: the relation between generation of electricity and total consumption of commercial power, both being expressed in terms of the same unit. If the fuels used in the production of electricity were excluded from the latter figure, the relevant values would be 17, 22 and 35 per cent, respectively, for the years 1937, 1949 and 1959. The calculation of the foregoing figures was based on the equivalences given on page 1, which are more in the nature of estimates than of statistical data. In the present study the term "coefficient of electrification" will be used henceforward, because, unlike the former expression, it does not necessitate the conversion of one type of energy into terms of another, by means of average coefficients of yield which are difficult to determine for each area and country, and are, moreover, variable through time.

The "coefficient of electrification" is defined as the quotient of total consumption of electricity, expressed in kWh, and net total consumption of commercial fuels (excluding fuels used for generating thermal electricity), expressed in kilogrammes of petroleum equivalent (see Energy in Latin America, op.cit., p.132)

5/ The coefficients of electrification given in table 9 differ from those presented in Energy in Latin America (op.cit) inasmuch as vegetable fuels are excluded from the calculation in the present instance. Although in this way they lose interest from the standpoint of comparison between countries which consume widely differing quantities of non-commercial fuels, they are still principally useful for the analysis of the evolution of the structure of energy consumption in one and the same country or area.

/Table 9

Table 9

COEFFICIENTS OF ELECTRIFICATION (kWh/kg OF PETROLEUM EQUIVALENT)

(Average rates of increase: percentages)

Year	Latin America	Western Europe	Eastern Europe	United States	Other developed countries	Reste of the world	World total
1937	0.660 a/	0.349	0.292	0.223	0.649	0.226	0.310
1949	0.689	0.567	0.343	0.423	0.790	0.310	0.470
1958	0.897	0.897	0.591	0.802	1.055	0.308	0.722
Average rates							
1937-58	1.5	4.6	3.4	6.3	2.3	1.5	4.4
1949-58	3.0	5.2	6.2	7.4	3.3	-0.1	5.7

Source: For Latin America: ECLA, on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 3.

a/ 1938.

/power that

power that requires heavy investment for its generation and distribution[6/] and a lengthy process of programming, such countries sometimes resort to the use of petroleum derivatives in its stead, for various activities, because these products are readily obtainable in the world market.

(b) Importance of hydroelectric resources

The possession of abundant hydroelectric resources is undoubtedly promoting electrification, as evidenced by the fact that the countries showing the highest proportion of hydroelectric power in their electricity production (see table 10) also register the highest electrification ccefficients. This applies to the group of countries composed by Japan, Canada, New Zealand, etc., to Latin America and to Western Europe.

It is none the less true that countries well endowed with deposits of such fuels as lend themselves to highly economic exploitation are also in an excellent position for successfully tackling their electricity supply problem.

In Latin America as a whole the proportion of hydroelectric generation remained almost stationary at about 50 per cent during the past two decades, while its share in the world total declined from 43 per cent in 1937 to 32 per cent in 1959. Only Eastern Europe (the figures for which are affected by the rapid development of the Soviet Union's hydraulic resources) registered a significant increase in the part played by hydroelectricity in total generation during the last twenty years. However, where Latin America's public generating services alone were concerned, the contribution of hydroelectric energy to their output did increase, rising from 43 to nearly 61 per cent, as will be shown in detail later.

In the more developed countries, the most economic sites have already been incorporated into production, so that interest in the increasingly

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6/ Thus, average investment requirements for the dispatch of 1,000 kWh of hydro power per annum at the consumer centre amount to approximately 150 dollars, while for the mechanical equivalent in terms of fuel oil (300 kg.) only 25 dollars need be invested. If instead of mechanical power the basis of comparison is thermal power, the disproportion is even greater.

/Table 10

Table 10

SHARE OF HYDRO POWER IN ELECTRICITY PRODUCTION

(Percentages)

Region or country	1937	1949	1955	1959
Latin America	50.8	51.4	49.6	52.2
Western Europe	44.5	41.9	41.0	42.1
Eastern Europe	11.5	9.7	11.2	16.8
United States	37.0	30.8	19.0	20.0
Other developed countries a/	74.3	77.6	71.5	69.6 b/
Rest of the world	46.2	51.4	23.0	26.3 b/
World total	42.7	38.8	30.6	31.9 b/

Source: For Latin America: ECLA, on the basis of direct information; for other regions and countries, United Nations, Statistical Papers, Ser. J, Nos. 1 to 3.

a/ Australia, Canada, Japan, New Zealand and the Union of South Africa.
b/ 1958.

/unattractive sites

unattractive sites remaining is growing less. Again, many of the less advanced countries, under pressure from developing industries and the demand for higher levels of living, and handicapped by lack of information on their hydroelectric sources, have often elected to construct thermo-electric plants, which can be built more rapidly and with a smaller initial investment, without much attention to the long-term implications of such decisions. This tendency is to be found in some Latin American countries that are comparatively well endowed with hydroelectric potential.

Chapter II

POWER CONSUMPTION AND ECONOMIC DEVELOPMENT

Power in almost all its forms - electricity, liquid fuel, coal, etc. - has a two-fold part to play in the economic system. It is at once a final consumer good and an intermediate good, and hence an essential element in almost all productive processes whether of goods or of services, although in this respect it is used predominantly for consumption in the industrial sector.

The level of power input is one of the factors determining productivity in manufacturing which in its turn directly influences the level of per capita income of the community. The level of per capita income in itself has a direct influence on power consumption by final consumers, not so much as a result of the capacity to purchase energy itself as in relation to the means to acquire durable consumer goods which need power in its various forms for their operation.

The foregoing remarks illustrate the close interdependence not only between income levels and electricity consumption but also between the latter and the rate of investment in the economy. It is to be noted that, in general, increased use of power supply both as a productive factor and as a final consumption good requires prior investment by the purchaser. In this sense then, the demand for power is a "derivative" of investment in equipment and machinery which require power supply as input.

The fact that such interdependence should exist at all means that the level of income unquestionably determines the level of total power consumption and to a much lesser extent the level of electricity consumption since there are occasions when one form of power is substituted by another. The rate of such substitution is measured by variations in the coefficient of electrification.

/The reasons

The reasons for there being no simple functional relationship between income and power consumption are many and fairly obvious. One of these for instance is the structure of the system of production. Different countries may achieve the same level of income with a very different breakdown in their output; this will make power consumption patterns different, since power input as a productive factor per unit output varies widely between the agricultural sector, services and manufacturing. Average input will also vary from one sector to another according to the particular sector's composition in terms of its basic activities.

In an earlier publication,[1/] using the information collected for the average of the years 1949-51 covering some 50 countries - including all the Latin American countries - an analysis was made of the relationship between net consumption of total energy and gross product measured in 1950 prices. (See figure I.) A similar study has now been made of the correlation between net consumption of commercial energy and gross product on the basis of information corresponding to the average for 1955-58 relating to 55 countries. (See figure II.)

An analysis of both figures would seem to confirm a hypothesis already shown to be valid on other occasions; that is that the income-elasticity of total power - the relationship between percentage increases in power consumption and in gross product - is slight at low income levels, rises considerably at intermediate income levels, only to decline again at the higher income levels. The decline in the latter instance should be attributed basically to an increase in the yield from power use and partial saturation of domestic consumption.

The aforementioned study contained an analysis for a number of Latin American countries of the historical changes in the consumption of total power as related to fluctuations in income levels. The conclusion reached was that consumption of total power had grown slightly more slowly than gross product. The efficiency of use of energy in the area has not yet improved at a rate rapid enough to explain such a phenomenon, particularly if it is realized that in the Latin American countries there has been a fair increase in production in the sectors

1/ Energy in Latin America, (E/CN.12/384/Rev.1), op.cit.

ORDER OF COUNTRIES

(Figure I)

1. United States of America
2. Canada
3. Switzerland
4. New Zealand
5. Sweden
6. United Kingdom
7. Australia
8. Denmark
9. Norway
10. France
11. Belgium and Luxembourg
12. Venezuela
13. Netherlands
14. Argentina
15. Federal Republic of Germany
16. Israel
17. Ireland
18. Spain
19. Uruguay
20. Cuba
21. Finland
22. Italy
23. Chile
24. Costa Rica
25. Austria
26. Union of South Africa
27. Panama
28. Yugoslavia
29. Mexico
30. Colombia
31. Brazil
32. Turkey
33. Greece
34. Portugal
35. Egypt
36. Guatemala
37. Honduras
38. Dominican Republic
39. El Salvador
40. Nicaragua
41. Japan
42. Ecuador
43. Peru
44. Ceylon
45. Southern Rhodesia
46. Paraguay
47. Thailand
48. Haiti
49. Bolivia
50. India
51. Northern Rhodesia
52. Congo (Leopoldville)

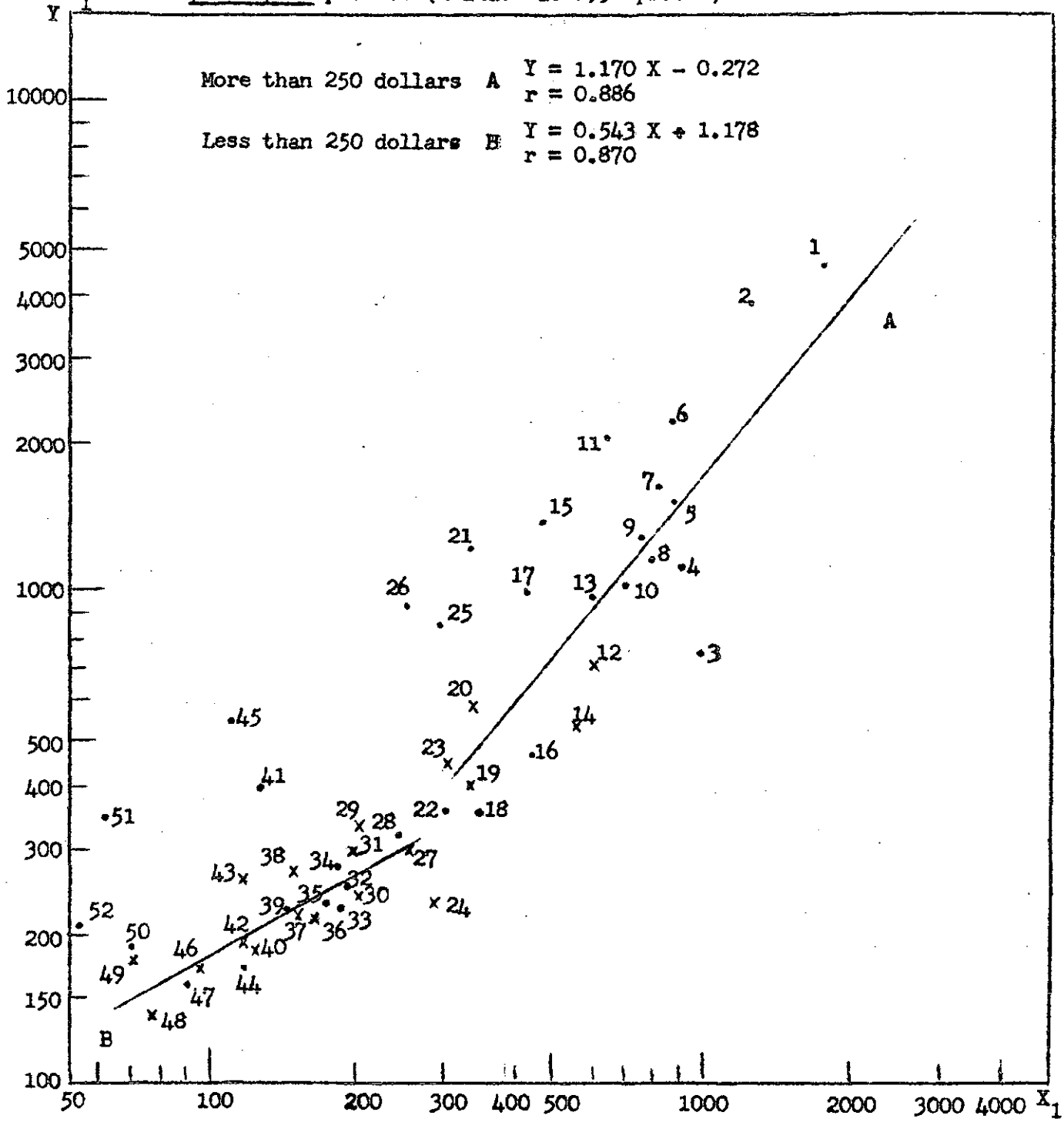
Figure I

CORRELATION BETWEEN NET PER CAPITA CONSUMPTION OF TOTAL ENERGY AND THE GROSS PER CAPITA PRODUCT : AVERAGE 1949-51

Logarithmic scale

Y = Net per capita consumption of total energy (kilogrammes of petroleum equivalent)

X_1 = Gross per capita product (dollars at 1950 prices)



/Figure II

ORDER OF COUNTRIES

(Figure II)

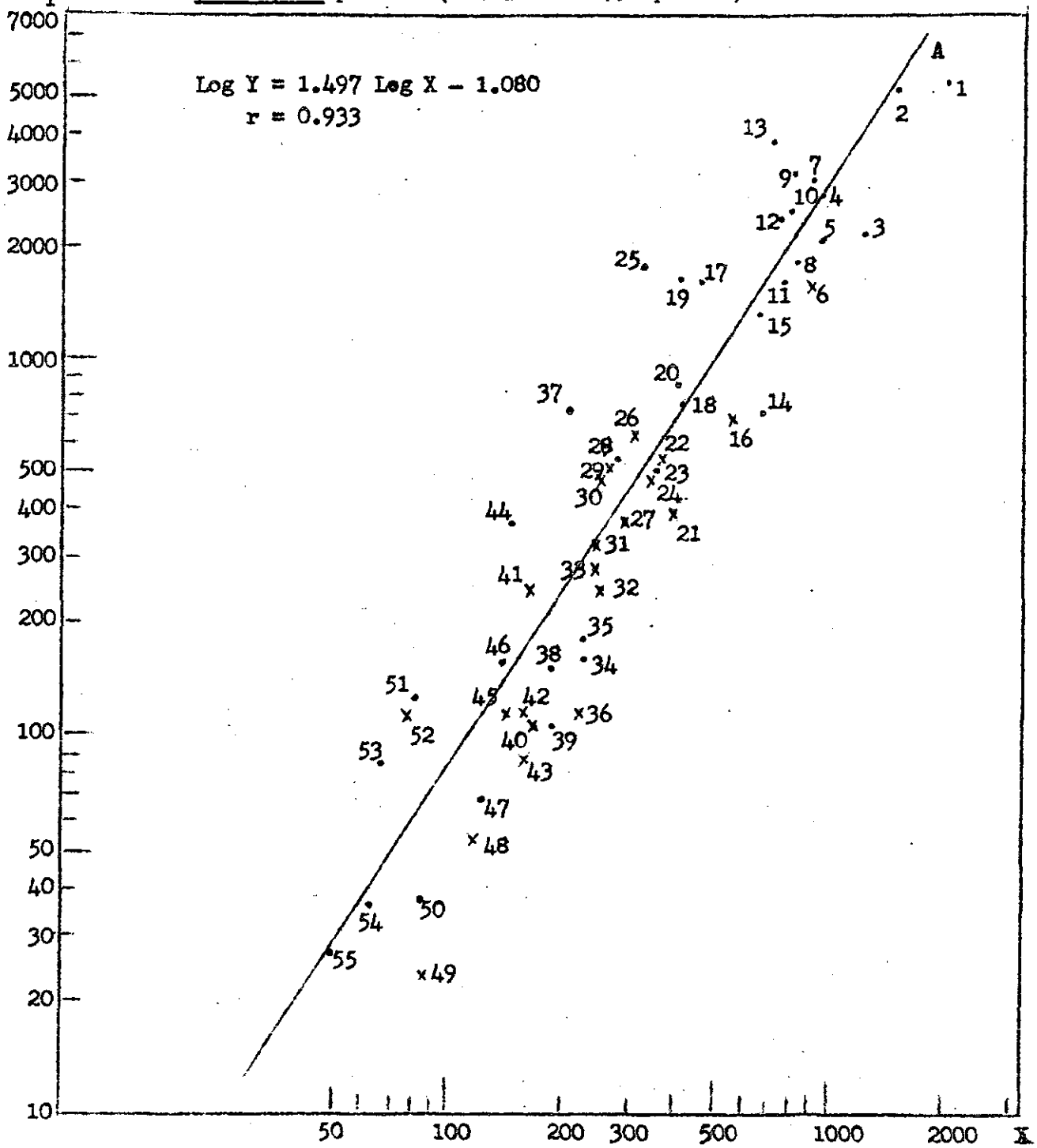
1. United States of America
2. Canada
3. Switzerland
4. Belgium and Luxembourg
5. New Zealand
6. Venezuela
7. Sweden
8. France
9. United Kingdom
10. Australia
11. Denmark
12. Federal Republic of Germany
13. Norway
14. Israel
15. Finland
16. Argentina
17. Netherlands
18. Italy
19. Austria
20. Ireland
21. Cuba
22. Uruguay
23. Yugoslavia
24. Surinam
25. Union of South Africa
26. Chile
27. Panama
28. Spain
29. West Indies
30. Mexico
31. Colombia
32. Costa Rica
33. Brazil
34. Turkey
35. Portugal
36. Dominican Republic
37. Japan
38. Greece
39. Nicaragua
40. El Salvador
41. Peru
42. Guatemala
43. Honduras
44. Federation of Nyasaland
45. Ecuador
46. Egypt
47. Ceylon
48. Paraguay
49. Haiti
50. Pakistan
51. Bolivia
52. Congo (Leopoldville)
53. India
54. Thailand
55. Burma

Figure II

CORRELATION BETWEEN NET PER CAPITA CONSUMPTION OF COMMERCIAL ENERGY AND THE GROSS PER CAPITA PRODUCT : AVERAGE 1955-58

Logarithmic scale

Y = Per capita energy consumption (kilogrammes of petroleum equivalent)
X = Gross per capita product (dollars at 1950 prices)



× = Latin American countries

• = Non-Latin American countries

/which are

which are the largest specific consumers of power. The cause of this would then seem to be trends in demand for power as a consumer good. Household consumption has not fluctuated greatly as income has not reached levels at which income-elasticity of consumption is high.

Most of the general observations made regarding total power are also valid if applied exclusively to demand for electric power. Such demand, however, has its own special characteristics closely linked to the general process of innovation and technical advances, and this explains why, historically, the rate of increase of electricity consumption greatly exceeds the rate of increase of gross product. Consumption of electricity has even been known to increase during periods when gross product has fallen.

Even taking into account the limitations of the simple correlation method, particularly if applied to economic series which by their nature increase with time, it was thought as well to compare the regression line on the gross product-electricity consumption diagram (expressed in logarithmic co-ordinates) corresponding to the years 1949-51 for 55 countries (including Latin America, the United States, Canada and Western Europe) 2/ with the line obtained in the same way and for the same countries but for the years 1955-58. (See figure III.)

Both the degree of correlation and the angular coefficient of both lines - equal to the income elasticity of consumption - turned out to be practically the same. The regression line, however, corresponding to the more recent period lay above the line for the earlier period with a vertical shift of approximately 60 per cent in comparison with the ordinates of the previous line.

The value of such a comparison lies in the fact that the vertical shift of the regression line over a period of seven years may be taken as an index of the rate of electrification in the economy, or the degree to which - for a given level of income - average electricity consumption has increased in the group of countries referred to. In other words, the vertical shift of the regression line is an indication of the internal dynamics of the electrification process and makes it possible

2/ Ibidem, figure III, page 32.

ORDER OF COUNTRIES

(Figure III)

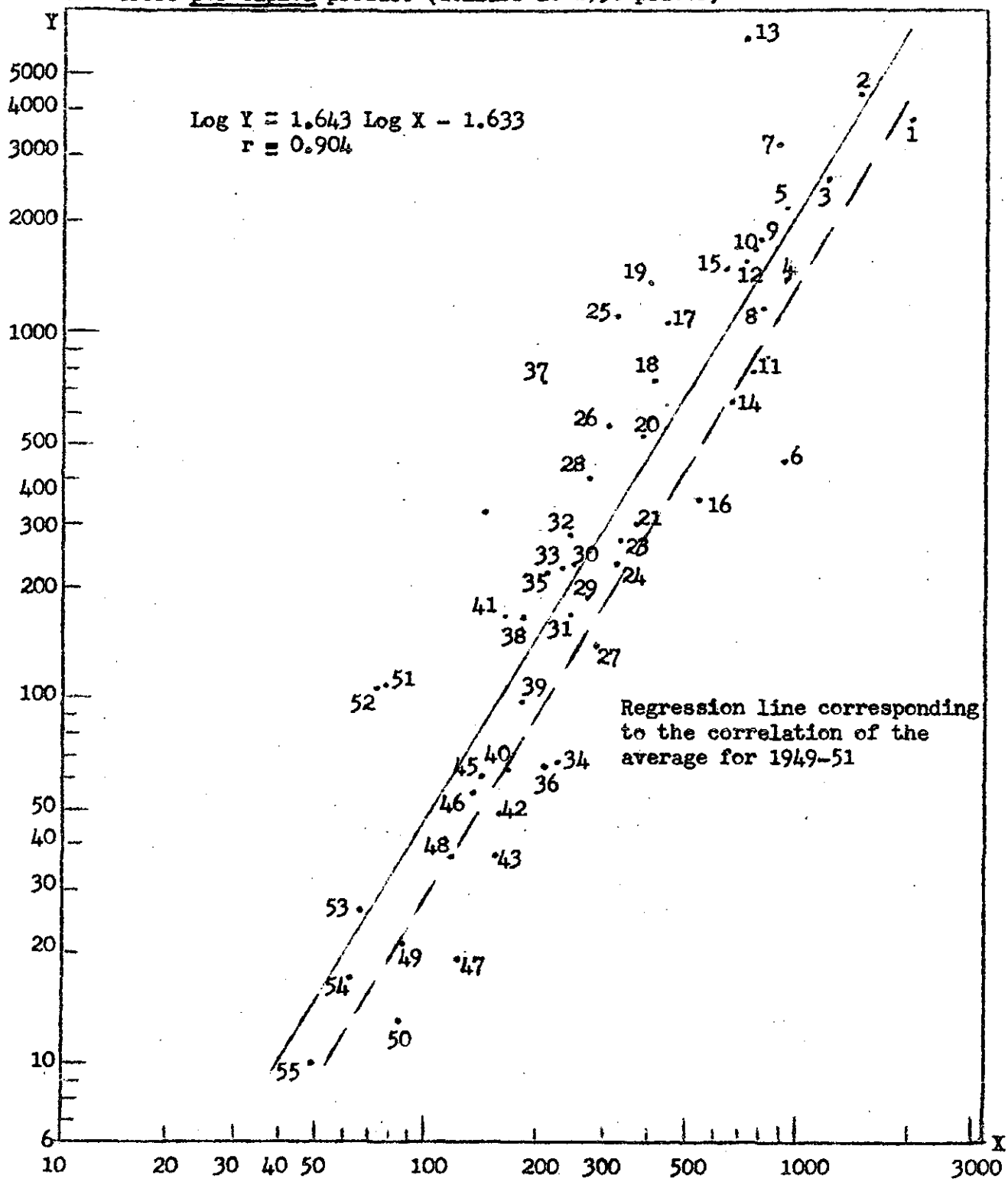
1. United States of America
2. Canada
3. Switzerland
4. Belgium and Luxembourg
5. New Zealand
6. Venezuela
7. Sweden
8. France
9. United Kingdom
10. Australia
11. Denmark
12. Federal Republic of Germany
13. Norway
14. Israel
15. Finland
16. Argentina
17. Netherlands
18. Italy
19. Austria
20. Ireland
21. Cuba
22. Uruguay
23. Yugoslavia
24. Surinam
25. Union of South Africa
26. Chile
27. Panama
28. Spain
29. West Indies
30. Mexico
31. Colombia
32. Costa Rica
33. Brazil
34. Turkey
35. Portugal
36. Dominican Republic
37. Japan
38. Greece
39. Nicaragua
40. El Salvador
41. Peru
42. Guatemala
43. Honduras
44. Federation of Nyasaland
45. Ecuador
46. Egypt
47. Ceylon
48. Paraguay
49. Haiti
50. Pakistan
51. Bolivia
52. Congo (Leopoldville)
53. India
54. Thailand
55. Burma

Figure III

CORRELATION BETWEEN NET PER CAPITA CONSUMPTION OF TOTAL ELECTRICITY AND THE GROSS PER CAPITA PRODUCT : AVERAGE 1955-58

Logarithmic scale

Y = Net per capita consumption of total electricity (kwh)
X = Gross per capita product (dollars at 1950 prices)



/to analyse

to analyse that process separately from what might be called the natural increase in electricity consumption coinciding more directly with rises in gross product.

In terms of this diagram the increase in demand for electricity in a given country may be described over time as the result of two concurrent movements or, in geometric terms, as the sum of two vectors, the first of which would be a movement along the consumption-income regression line corresponding to increases in consumption and income, and the second a vertical shift of the line itself resulting from technical advances, a more even distribution of income and the replacement of other forms of power by electricity.

Clearly that does not mean that both movements are independent; on the contrary, it is well known that innovations and technical advances coupled in particular with wider income distribution which largely explain the growing rate of electrification per unit of gross product, are in their turn one of the main forces behind investment and the general process of economic development.

For the group of countries referred to be taken as a whole, per capita electricity consumption grew by 8 per cent per annum between the 1949-51 period and the 1955-58 period. About 3.5 per cent of this increase would seem to be closely linked to overall increases in income and the remainder would seem to be the more direct result of the other three factors referred to. This comment is an indication of the care that must be taken in using relationships such as that used in figure III (which gives consideration only to the effect of income fluctuations on electricity consumption) for the projection of consumption and demand in a country or area.

This phenomenon is equally true in Latin America where the operation which has just been described was repeated for the same period and for the Latin American countries alone. (See figure IV.) The results are, however, quantitatively less conclusive because of the more widely scattered and smaller number of points of reference.

/Nonetheless it

Nonetheless it should be pointed out that the regression line corresponding to the years 1956-58 lies above the regression line for 1948-50 with a vertical shift of only one third in relation to the ordinates of the 1956-58 line. This means that on an average, increases in electricity consumption in Latin America as a direct result of a more even distribution of income, technical progress and its substitution for other forms of power are occurring at a slow rate in comparison with the majority of areas in the world.

A separate diagram (figure V) shows, also in logarithmic co-ordinates, the relationship for each country between net per capita consumption of electricity and gross per capita product for the averages of the years 1948-50 and 1956-58. The vectors for each country and for the area joining the extremes permit an appraisal of the characteristics and intensity of trends in electricity consumption during the eight years of the period under consideration. The slope of the vector representing Latin America as a whole is approximately 3. This means that electricity consumption increased as almost the cube of gross product. In the countries of Western Europe as a whole, however, for the period 1950-57, electricity consumption varied approximately as the square of gross product. This does not necessarily mean that such a difference is an automatic result of the different level of economic development in the two areas. In the United States, for example, the economy has over the last fifteen years grown at a rate of some 3 per cent per annum, which is considerably below the average for Western Europe and nonetheless electricity consumption increased there at a rate of nearly 10 per cent.

The increase shown for Latin America can be explained by the slow growth of per capita gross product (2 - 2.5 per cent annually) more than by the corresponding increase in electricity consumption.

The vectors representing Mexico, the West Indies and Nicaragua have a gentler slope that the rest, and this is an indication of the fact that in the last decade the dynamic sectors of production in those countries (agriculture in all of them, in addition to industry in Mexico and petroleum in the West Indies) have not been such large consumers

/Figure IV

ORDER OF COUNTRIES

(Figure IV)

1. Argentina
2. Bolivia
3. Brazil
4. Colombia
5. Chile
6. Ecuador
7. Paraguay
8. Peru
9. Uruguay
10. Venezuela
11. Costa Rica
12. Cuba
13. El Salvador
14. Guatemala
15. Haiti
16. Honduras
17. Mexico
18. Nicaragua
19. Panama
20. Dominican Republic
21. West Indies
22. Surinam

Figure IV

LATIN AMERICA : CORRELATION BETWEEN NET PER CAPITA CONSUMPTION OF ELECTRICITY AND THE GROSS PER CAPITA PRODUCT : AVERAGE 1956-58

Logarithmic scale

Y = Net per capita consumption of electricity (kwh)
X = Gross per capita product (dollars at 1950 prices)

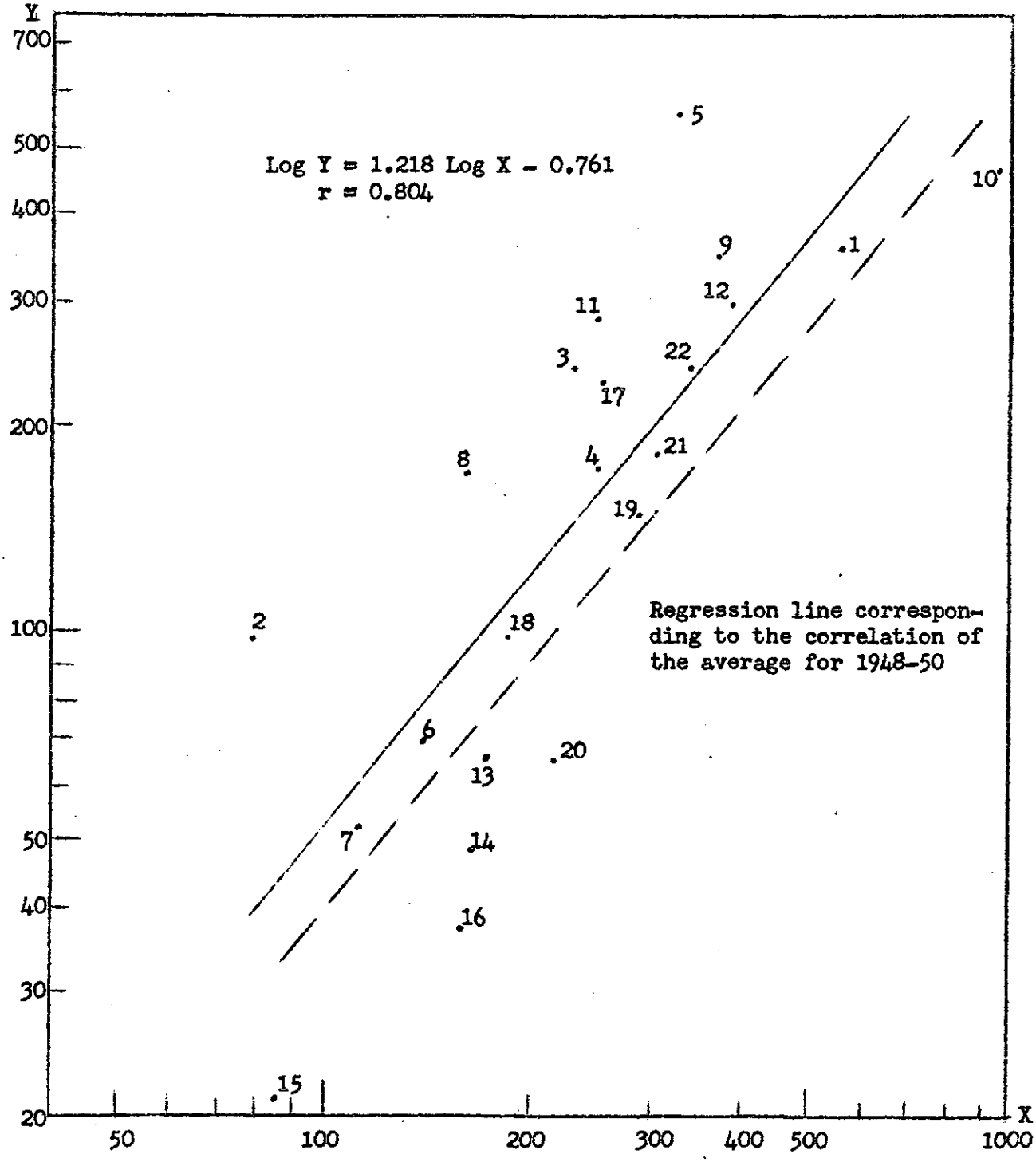
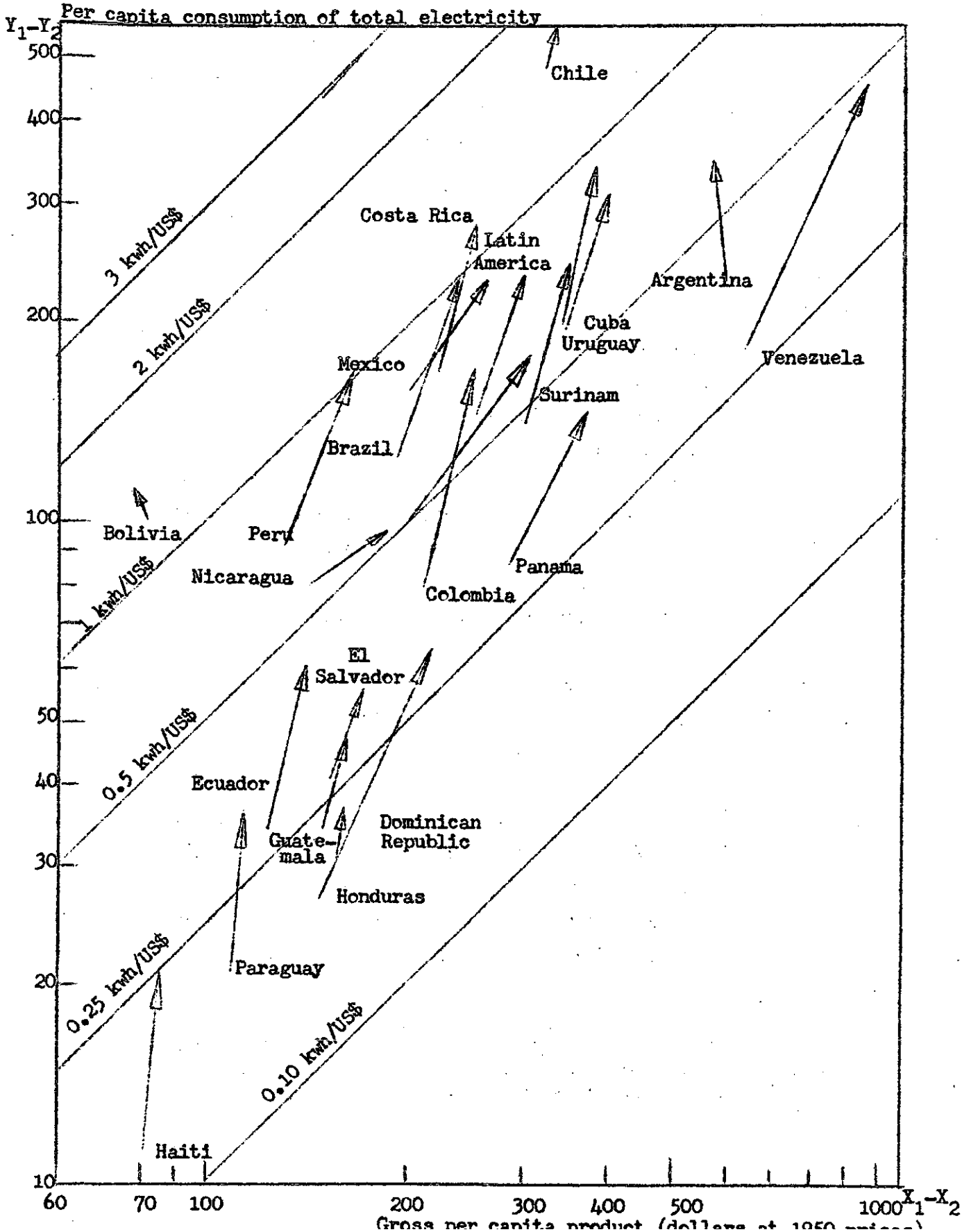


Figure V

LATIN AMERICA : COMPARATIVE EVOLUTION OF NET PER CAPITA CONSUMPTION OF TOTAL ELECTRICITY AND THE GROSS PER CAPITA PRODUCT : AVERAGES 1948-50 AND 1956-58
(Logarithmic scale)



of electric power per unit of gross product as mining and the manufacturing industry in Peru and Chile or the manufacturing industry alone, for example, in Argentina, Brazil, Colombia and Uruguay.

The parallel lines, each one of which represents a constant level of consumption of electricity per dollar of gross product (3, 2, 1, etc. kWh/US$, at 45°), help with the rapid assessment in quantitative terms of the various levels of consumption.

Only the vector representing Nicaragua has an angle of slope slightly less than those mentioned above. This indicates that electricity consumption in the country has grown at a slower rate than per capita product. The lines corresponding to Argentina and Bolivia have a slope that shows the opposite to be true, namely, that electricity consumption has increased (in Bolivia very slightly) despite the decline in gross product. This is further evidence of the highly dynamic character of this form of power. It is interesting to note that in Bolivia more than 35 per cent of the electricity generated is intended for the mining industry, and it is precisely the reduced level of activity in that sector that is an important cause of the fall in national production.

Latin America as a whole and half the other countries of the world consumed between 1.0 and 0.5 kWh per dollar of gross product during part or all the period 1948-50 and 1956-58.3/

Chile, Bolivia and Costa Rica have clearly exceeded a consumption figure of 1 kWh/dollar of gross product, the first two as a result of the high level of electricity input in their mining and metallurgical industries and the latter as a result of its high rate of domestic consumption. Table 11 gives, for the various countries, figures of total net electricity consumption per unit of national product for the averages

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3/ As an example of electricity consumption in other countries outside the area the following figures were registered for 1958 (kWh per dollar of gross product): Federal Republic of Germany 2.25; United Kingdom, 2.10; Italy, 2.10; USA, 1.99; France, 1.67; Spain, 1.62; India, 0.62.

/of the

of the years already indicated above. It also gives a figure for the cumulative rates of average annual growth which for the area as a whole is as high as 4.3 per cent.

Figure VI shows fluctuations in electricity consumption as related to variations in income, year by year, for Latin America as a whole and also for a number of specific countries and illustrates trends in total generation per unit of gross product in the last twenty years.

Despite marked differences in rates of increase between one country and another, it can be seen that electricity consumption has grown much faster than the corresponding increase in production. Annual fluctuations are in particular an indication of the slow reaction of electricity consumption in response to rapid variations in gross product; electricity consumption does not reflect to any great extent the variations in gross product particularly in periods when the latter declines. In the countries for which the curves cover the war period, note should be taken of the simultaneous increase in product resulting from rises in exports and lag in generation as result of the difficulty of supplying the equipment which the electricity industry needs.

Coefficients of electrification

In the foregoing chapter, attention was drawn to the useful part played by the coefficient of electrification in studying, in particular, trends in electricity consumption as related to other forms of commercial power; in this connexion, it should be noted that for Latin America as a whole the figures for electricity consumption were as follows: 0.660 in 1938, 0.689 in 1949 and 0.929 in 1959. Table 12 shows the values of this coefficient by countries for the years 1938, 1949, 1955 and 1959.

The countries which easily exceeded the average coefficient for the area in 1959 included Paraguay, Haiti and the Dominican Republic not as a result of high electricity consumption (they are the smallest consumers of this kind of power) but because of their very low rate of commercial fuels consumption. In Costa Rica both factors are present, namely, electricity consumption above the regional average

/Table 11

Table 11

LATIN AMERICA: NET CONSUMPTION OF ELECTRICITY PER UNIT OF GROSS PRODUCT

(In dollars at 1950 prices)

Country	kWh/dollars		Average annual rate of increase (percentage)
	1948-50	1956-58	
Argentina	0.440	0.626	4.5
Bolivia	1.235	1.594	3.2
Brazil	0.653	1.017	5.7
Chile	1.547	1.713	1.3
Colombia	0.378	0.688	8.0
Ecuador	0.276 a/	0.440	6.0
Paraguay	0.196	0.327	6.6
Peru	0.713	1.049	5.0
Uruguay	0.573	0.915	6.0
Venezuela	0.296	0.488	6.5
Costa Rica	0.796 a/	1.128	5.1
Cuba	0.590	0.805	4.0
Dominican Republic	0.185	0.301	6.3
El Salvador	0.265 a/	0.384	5.5
Guatemala	0.230 a/	0.293	3.5
Haiti	0.138 b/	0.247	8.1
Honduras	0.203 a/	0.231	1.9
Mexico	0.783	0.898	1.7
Nicaragua	0.576 a/	0.530	-1.2
Panama	0.309	0.402	3.3
Surinam	0.478 b/	0.709	5.4
Trinidad, Tobago and Jamaica	0.508 c/	0.593 d/	3.1
Latin America	0.584	0.816	4.3

Source: Information supplied direct and various publications prepared by ECLA.

Note: The figures in brackets are ECLA estimates.

Table 12

LATIN AMERICA: COEFFICIENT OF ELECTRIFICATION

(kWh/kg of petroleum equivalent)

Country	1938	1949	1955	1959
Argentina	0.435	0.676	0.605	0.813
Bolivia	3.272	2.373	1.500	1.539
Brazil	...	...	1.420	1.431
Chile	1.321	1.640	1 253	1.603
Colombia	0.522	0.687	0.650	0.773
Ecuador	...	0.549	0.671	0.837
Paraguay	...	...	4.000	1.044
Peru	1.198	0.706	0.866	1.422
Uruguay	0.409	0.619	0.802	0.976
Venezuela	0.449	0.287	0.321	0.446
Costa Rica	...	1.550	2.637	2.285
Cuba	...	0.824	0.821	1.029
Dominican Republic	(0.488)	(1.824)	(0.967)	(1.273)
El Salvador	...	1.057 a/	0.826	1.005
Guatemala	...	0.379	0.484	0.601
Haiti	...	...	(0.593)	...
Honduras	...	0.382 a/	0.451	0.434
Mexico	0.709	0.606	0.668	0.693
Nicaragua	...	1.953 a/	1.206	0.956
Panama	1.875	0.545	0.489	0.732
British Guiana	...	(0.940)	(0.328)	...
Surinam	...	(0.369)	(0.513)	...
Trinidad, Tobago and Jamaica	...	(0.538)	(0.624)	...
Latin America	0.660	0.689	0.797	0.929

Note: The figures in brackets are ECLA estimates.

a/ 1950.

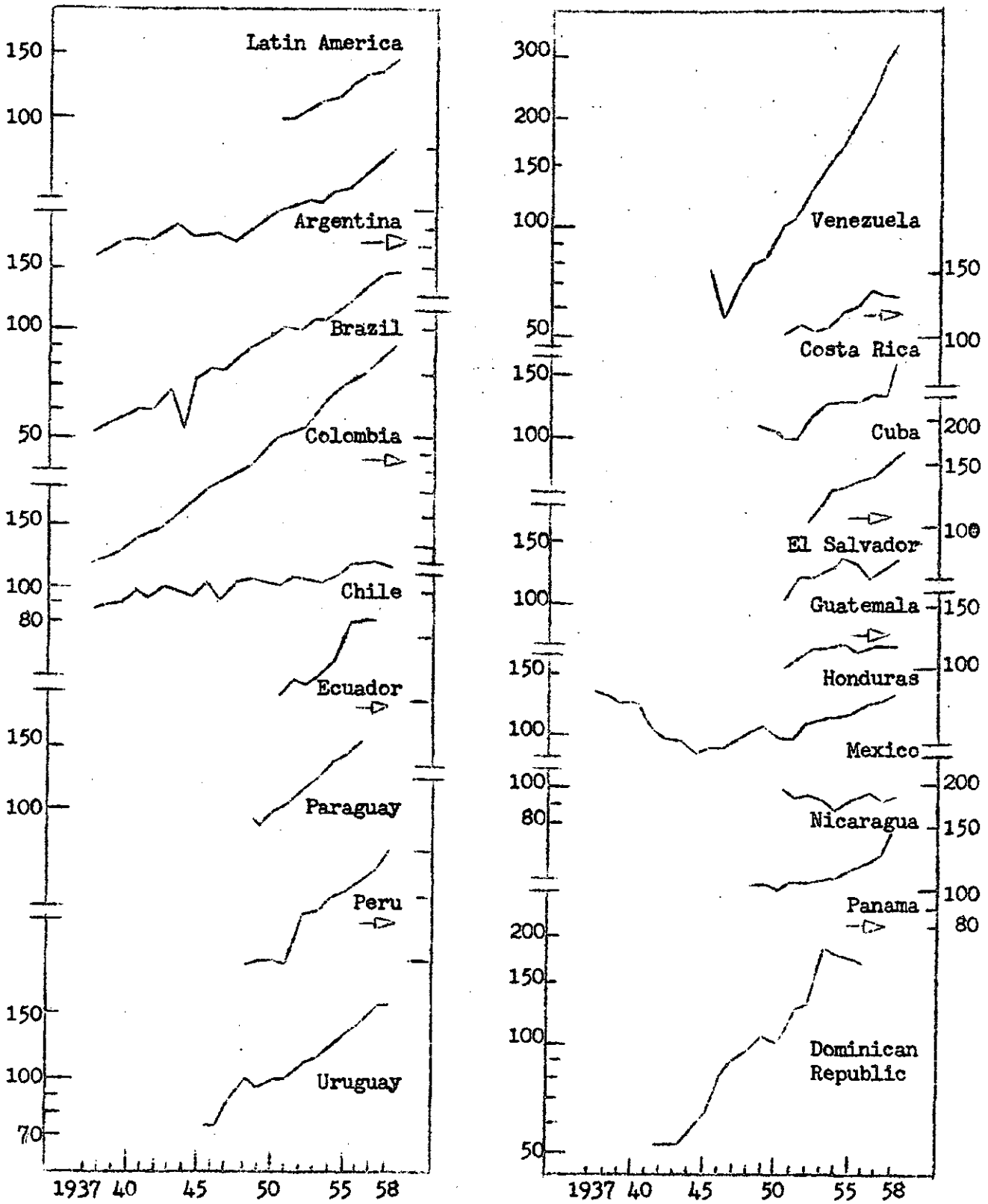
/Figure VI

Figure VI

LATIN AMERICA : EVOLUTION OF ELECTRICITY GENERATION PER UNIT OF GROSS PRODUCT

(Index : 1950 = 100)

Semilogarithmic scale



Note : Electricity production in Venezuela is by the public utility only

and consumption of fuels below the regional average. Among the countries with a high coefficient: Bolivia, Brazil, Chile, Peru and Uruguay show, within a better balanced distribution pattern of the utilization of commercial power, a preference for the use of electricity; Ecuador, Colombia and Mexico, which cover large proportions of their petroleum consumption with domestic production, have a similar distribution to the aforementioned countries although with a coefficient of electrification below the regional average. The same occurs in Argentina, although that country's production of hydrocarbons only started increasing to any appreciable extent in 1960. Although Venezuela, which is a large petroleum producer, had the highest per capita electricity consumption in 1959, it had one of the lowest coefficients, because it consumes predominantly commercial fuels.

The slow - and even negative - trend of the coefficient of electrification in the majority of the Latin American countries during the last decade (with rare exceptions such as Peru, Uruguay and Venezuela) means that the rate of growth throughout the area is very far below the world average and this mainly due to electricity supply being far below demand.

Chapter III
ELECTRICITY PRODUCTION IN LATIN AMERICA

1. General observations

It has already been seen that electricity production and consumption in Latin America have risen more rapidly than average income. In fact, the relation kWh per dollar of gross product increased at the cumulative annual rate of 4.3 per cent during the '50's. But this is by no means an indication that the supply has been adequate. On the contrary, after the Second World War, the shortage of electricity in a number of countries was a serious impediment to the development of their economies, discouraging the creation of new industries in some cases and hampering the expansion or mechanization of those already in existence.

In Latin America, as in many under-developed countries in other regions, the war marked the beginning of a period characterized by a tremendous upsurge of electricity demand, as the result of a rapid increase in the urban population with the corresponding demand for a higher level of living and the expansion of industrial activities that are becoming increasingly dependent on this form of energy.

A great many systems which are faced with a demand that is above their capacity have had to cope with requirements under deficient conditions, i.e. low voltages, frequency instability, interruptions, rationing, and restrictions on the admission of new consumers or on any expansion in demand among old subscribers.

The low yields for generation and distribution by these overburdened systems, which have been unable properly to replace or enlarge their installations - usually for lack of funds - have led to even greater savings on the part of the institutions running them. Hence many industries have been forced to set up thermoelectric plants, with components that are unrelated to their own technical processes, because of the deficiencies in the public service supply. The main consequence of electricity production in private plants with a small capacity is the high cost of the kWh, although there are exceptions in, for example, the paper

making, iron and steel and cement industries, which need such a large volume of energy that they have to have big plants from which a satisfactory thermal yield can be obtained.

The evolution of electricity generation in the last twenty years is not fully representative of potential demand in the Latin American countries, since generating capacity has been affected in nearly all of them by restrictions on supply, although to different degrees and at different times. Experience indicates that if electricity demand remains unsatisfied for a long time (three years or more), the economic development of the region in question is apt to be affected to such an extent that a long period of unlimited supplies is required before the level which would have been reached without rationing can be recovered.

Production statistics generally refer to energy measured at generating terminals, but it has not been possible to standardize this criterion, since in some countries the information may be based on measurements taken at other points on the circuit, and may even discount internal consumption at the power station itself (up to 2 per cent of the energy generated at hydro plants and twice as much in thermal plants).

The data from the private sector[1/] are generally deficient, and in more than a few cases contradictory series exist which make it difficult or impossible to determine the reliable figures. This situation does, however, seem to have improved in the last few years.

It has therefore been thought best for the purposes of this study to econcentrate on the development of the public sector, but to comment on the joint situation of the public and private sectors whenever reliable

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1/ The private or self-supplying service is constituted by the institutions that produce electricity entirely or almost entirely for their substantive activities (mining, petroleum extraction, sugar refining, cement and pulp and paper manufacture, iron and steel making, etc.), either because they are far from the public electricity service, or because this service cannot meet their demands to the extent or in the way required of it, or because the industrial thermal cycle makes it economically advisable for a certain amount of the electricity they require to be self-supplied.

/information is

information is available or when stress should be laid on special cases in which the private sector is of great importance. This applies to economies in which the principal export activity is based on mining products and petroleum (Surinam, Peru, Chile, Venezuela, Bolivia), or on both agricultural and industrial production with a high specific consumption of electricity - mechanical irrigation, sugar refining, etc. (Honduras, Nicaragua, Haiti, Cuba, Dominican Republic).

2. Generation

(a) Public utilities and self-suppliers

In 1959, joint electricity generation by the public and private sectors in Latin America amounted to 62,600 million kWh, as against 12,600, 26,300 and 42,600 million kWh in 1938, 1949 and 1955 (see table 13), its annual rate of growth rising progressively from 7.9 per cent in 1938-59 to 9.1 per cent in 1949-59 and to 10.1 per cent in 1955-59.

(b) Share of public utilities in total generation

There was a gradual but general expansion in the share of Latin America's public utilities in total electricity generation. From 70.4 per cent in 1938 it increased to 79.5 per cent in 1959. During the Second World War and the immediate post-war years it decreased temporarily, contracting to about 65 per cent in 1947 owing to irregularities in the supply of equipment and materials, as explained in chapter IV.

As the supply of heavy equipment on the international market - manufactured to buyers' specifications - subsequently reverted to normal, and at the same time the Governments began to programme and systematize electric power development, the public utilities reacted favourably and enlarged their share of total generation. In 1959, the situation varied considerably from one country to another (see table 14). At one extreme was Uruguay, where there is practically no generation of electricity for private use, followed closely by El Salvador, Costa Rica and Brazil and at the other, countries such as Surinam, Peru, Honduras and Chile,

Table 13

LATIN AMERICA: ELECTRICITY GENERACION (PUBLIC AND PRIVATE) a/

(Millions of kWh)

Country	1938	1949	1955	1956	1957	1958	1959
Argentina	2 730	4 978	6 802	7 326	(8 307)	9 419	9 850
Bolivia	189	321	387	403	405	400	(426)
Brazil	2 987	7 610	13 655	15 447	16 963	19 766	21 108
Chile	1 634	2 877	3 847	4 019	4 188	4 156	4 598
Colombia	334	1 130	2 250	2 610	2 790	3 050	(3 348)
Ecuador	71	(115)	259	277	292	315	332
Paraguay	16	37	64	65	75	82	87
Peru	637 b/	1 050 c/	1 363 d/	1 625	1 668	1 992	2 212
Uruguay	234	573	1 022	1 066	1 154	1 236	1 175
Venezuela	(237)	(1 011)	(2 388)	2 707	(3 103)	(3 791)	(4 310)
Costa Rica	(85)	182	296	328	347	365	383
Cuba	(524)	1 198	1 842	2 063	2 357	2 588	2 806
El Salvador	(28)	88 e/	145	165	185	213	235
Guatemala	(42)	114 e/	165	171	193	219	243
Haiti	(24)	(40)	(60)	(70)	(80)	(90)	(90)
Honduras	(34)	50 e/	61	68	73	77	86
Mexico	2 512	4 328	7 002	7 827	8 453	9 057	9 800
Nicaragua	(51)	89 e/	124	132	139	150	174
Panama	35	83	134	145	172	205	228
Dominican Republic	(24)	146	195	232	258	284	316
British Guiana	(29)	(35)	55	60	67	70	(75)
West Indies f/	(87)	(248)	414	473	522	591	(631)
Surinam	(10)	(25)	43	51	61	57	61
Total Latin America	12 554	26 328	42 579	47 330	51 852	58 173	62 574

Sources: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.

a/ Further information is given in Statistical Annex C.

b/ 1940.

c/ 1952.

d/ 1954.

e/ 1950

f/ Trinidad, Tobago and Jamaica.

/Table 14

Table 14

LATIN AMERICA: GENERATION BY THE PUBLIC SERVICE AND ITS PROPORTION OF TOTAL GENERATION a/

(Millions of kWh and percentages)

Country	1938		1949		1955		1959	
	Millions of kWh	Percentage	Millions of kWh	Percentage	Millions of kWh	Percentage	Millions of kWh	Percentage
Argentina	2 328	85.3	4 243	85.2	5 902	86.8	7 750	78.7
Bolivia	64	33.7	165	51.4	216	55.8	(281)	66.0
Brazil	(2 030)	(68.0)	(4 600)	(60.5)	12 532	91.8	19 625	93.0
Chile	639	39.1	1 023	35.6	1 853	48.2	2 260	49.2
Colombia	294	88.0	930	82.3	1 820	80.9	2 698	80.6
Ecuador	...	...	...	...	214	80.6	(266)	80.1
Paraguay	11	68.8	27	73.0	51	79.7	72	82.8
Peru	314	49.3	461	43.9	566	41.53	(971)	43.9
Uruguay	234	100.0	573	100.0	1 022	100.0	1 175	100.0
Venezuela	112	47.3	455	45.0	1 276	53.4	2 720	63.1
Costa Rica	...	...	158	86.8	265	89.5	360	94.0
Cuba	324	61.8	754	62.9	1 324	71.9	2 073	73.9
El Salvador	...	...	66	75.0	131	90.3	228	97.0
Guatemala	31	73.8	91	79.8	133	80.6	201	82.7
Haiti	...	...	...	...	23	38.3	(49)	54.4
Honduras	...	...	13	26.0	24	39.3	42	48.8
Mexico	2 120	84.4	3 513	81.2	5 616	80.2	7 897	80.6
Nicaragua	...	...	24	27.0	48	38.7	94	54.0
Panama	30	85.7	75	90.4	114	85.1	203	89.0
Dominican Republic	24	100.0	71	48.6	115	59.0	(257)	(81.3)
British Guiana	(12)	41.4	14	40.0	31	56.4	(49)	65.3
West Indies	...	...	96	38.7	255	61.6	(434)	68.8
Surinam	(4)	40.0	5	20.0	18	38.6	24	39.3
Total Latin America	(8 571)	70.4	17 357	66.3	33 549	78.8	49 729	79.5

Source: Direct information and ECLA publications.
Note: The figures in brackets are ECLA estimates.

a/ Further information in Statistical Annexes C and D.

/where productive

where productive activities have a high consumption level and the participation of the public utilities was less than 50 per cent.2/

During the last five years, public utilities played an increasingly important part in generation. The only exceptions were Colombia and Ecuador, where their share remained the same, and Argentina, where it decreased. These exceptions show that investment in the production and distribution of electric power was inadequate in comparison with investment in the general development of activities.

(c) Generation per country and per capita (1959)

Three countries in conjunction - Brazil, Argentina and Mexico -, whose joint population constitutes about 60 per cent of the total population of Latin America, accounted for 65 per cent of total electricity generation by the public and private sectors in the region. Fourteen other countries and territories (Bolivia, British Guiana, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Surinam, the West Indies (Trinidad, Tobago, Jamaica) accounted for little more than 5 per cent of generation, with a population that constituted about 16 per cent of the Latin American total. This indicates the relative importance of the bigger countries in the region's electricity production (see table 15).

With respect to per capita generation by the public and private sectors together - especially when regarded as an index of economic development - three different groups of countries may be distinguished in relation to the current regional average of 318 kWh/per capita: those that exceed it by a wide margin, those that are close to it and those that fall well below it (the limits being approximately one third of the average above and below). Although these divisions are arbitrarily

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2/ The extent to which the public utilities participated in the total generation of certain European countries in 1959 was as follows (in percentage terms): Sweden, 99, United Kingdom, 88, Italy, 82, Switzerland, 82, USSR, 76, France, 70, Federal Republic of Germany, 61, Belgium, 57 Economic Commission for Europe, The situation and prospects of Europe's electric power supply industry in 1959-60 (ST/ECE/EP/9). In the United States, the percentage was 89 per cent (Edison Electric Institute, Electric Industry Statistics).

Table 15

LATIN AMERICA: GENERATION IN 1959

Country	Population (thousands)	Total		Public service		
		Millions of kWh	kWh per capita	Millions of kWh	Percentage of total	kWh per capita
Argentina	20 708	9 850	476	7 750	79	374
Bolivia	3 383	(426)	(126)	(281)	66	(83)
Brazil	64 568	21 108	327	19 625	93	304
Chile	7 372	4 598	624	2 260	49	307
Colombia	13 950	(3 348)	(240)	(2 698)	81	(193)
Ecuador	4 128	(332)	(81)	(266)	80	(65)
Paraguay	1 716	87	51	72	83	42
Peru	10 524	(2 212)	(210)	(971)	44	(92)
Uruguay a/	2 787	1 175	422	1 175	100	422
Venezuela	6 505	(4 310)	(663)	2 720	63	418
Costa Rica	1 084	383	353	260	94	332
Cuba	6 662	2 806	421	2 073	74	311
El Salvador	2 490	235	94	228	97	91
Guatemala	3 677	243	66	201	83	55
Haiti	3 653	(90)	(25)	(49)	(54)	(13)
Honduras	1 872	86	46	42	49	22
Mexico	33 229	9 800	295	7 897	81	238
Nicaragua	1 414	(174)	(123)	94	54	(66)
Panama	1 012	228	225	203	89	201
Dominican Republic	2 760	316	114	(257)	81	(93)
British Guiana	549	(75)	(137)	(49)	65	(89)
West Indies b/	2 488	(631)	(254)	(434)	69	(174)
Surinam	255	61	239	24	39	94
Total Latin America	196 786	62 574	318	49 729	79	253

Source: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.
a/ The figures are for 1958, as production in 1959 was very affected by the floods in Uruguay.
b/ Trinidad, Tobago and Jamaica.

/fixed, they

fixed, they make it easier to analyse electric power development in the different countries (see table 16).

The first group consists of Chile, Venezuela and Cuba, which have a high level of production by private plants, mainly in connexion with the principal export activities (50.8, 36.9 and 26.1 per cent respectively). In the second group, Surinam, Peru and the West Indies are outstanding for the same reason with (60.7 and 56.1 and 31.2 per cent respectively).

Most of the countries show an increasingly rapid rate of growth, except for Chile and Uruguay in the first group, Costa Rica and Colombia in the second and Ecuador and Paraguay in the third (see table 17).

Up to 1957, Chile had the highest per capita consumption of any country in Latin America. From 1958 onwards, it was superseded by Venezuela where the exceptional rate of growth kept pace with its economic development for more than 15 years (15-16 per cent annually, i.e. duplication in four to five years).3/ In the third group, the absolute per capita increment is small and often less than the regional average (30 kWh/per capita). This is true of El Salvador, for instance, where the rate of growth is 12.8 per cent and the per capita increment in generation 12 kWh.

As regards generation by the public services exclusively, a classification on the same lines as the foregoing would show that the relative positions are fairly similar. The most marked increase in generation by the public services took place in the post-war years (1946-56) which were characterized by a general expansion in Latin America's economic activities. A decline was subsequently recorded in the rate of growth in most of the countries, mainly for the following reasons:

3/ During the same period, the gross product expanded at an average rate of 11 per cent annually, leading to an appreciable per capita increment in urban areas (purchases of electrical appliances for household use amounted to 100 million bolivares in 1956-58 at a yearly increase of 37 per cent, and industry developed at the annual rate of 11.3 per cent. Presidential Message to Congress, Four-year Plan 1960-64).

/Table 16

Table 16

LATIN AMERICA: ANNUAL GENERATION PER CAPITA AND TYPE OF SERVICE, 1959

Country	Total	Public	Private
First group			
Venezuela	(663)	418	(245
Chile	624	307	317
Argentina	476	374	(102)
Uruguay	433 a/	433 a/	-
Cuba	421	311	110
Second group			
Costa Rica	353	332	21
Brazil	327	304	23
Mexico	295	238	57
Surinam	239	94	145
West Indies	(254)	(174)	(80)
Colombia	(240)	(193)	(47)
Panama b/	225	201	25
Peru	(210)	(92)	(118)
Third group			
British Guiana	(137)	(89)	(48)
Bolivia	(126)	(83)	(43)
Nicaragua	(123)	(66)	57
Dominican Republic	114	(93)	21
El Salvador	94	91	3
Ecuador	(81)	(65)	(16)
Guatemala	66	55	11
Paraguay	51	42	9
Honduras	46	22	24
Haiti	(25)	...	...

Sources: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.

a/ See table 15, footnote a/.

b/ Excluding the Canal Zone for lack of information.

/Table 17

Table 17

LATIN AMERICA: ANNUAL RATE OF GROWTH OF ELECTRICITY GENERATION a/

(Percentages)

Country	Public and private			Public service		
	1938-59	1949-59	1955-59	1938-59	1949-59	1955-59
First group						
Venezuela	(14.8)	(15.6)	(15.9)	16.4	19.6	20.8
Chile	5.05	4.75	4.6	6.2	8.2	5.1
Argentina	6.3	7.1	9.7	5.9	6.2	7.0
Uruguay	8.8 b/	9.0 b/	6.6 b/	8.8 b/	9.0 b/	6.6 b/
Cuba c/	8.3	8.9	11.1	9.2	10.6	11.9
Second group						
Costa Rica	(7.4)	7.7	6.7	...	8.6	8.0
Brazil	9.7	10.8	11.5	...	...	11.9
Mexico	6.7	8.5	8.8	6.5	8.4	8.9
Surinam	9.0	8.4 d/	9.1	9.0	15.3 d/	7.5
West Indies	...	8.9 d/	11.1	...	14.7 d/	14.2
Colombia	(11.6)	(11.5)	(10.4)	(11.1)	(11.2)	(10.3)
Panama e/	9.3	10.6	14.2	9.5	10.5	15.5
Peru	6.8 f/	10.6 g/	10.2 h/	(6.1) f/	11.2 g/	(11.4)
Third group						
British Guiana	4.6	7.9	8.1	6.9	13.3	12.1
Bolivia	(3.9)	(2.9)	(2.4)	(7.3)	(5.5)	(6.8)
Nicaragua	6.0	7.7 i/	8.8	...	16.4 i/	18.3
Dominican Republic	...	8.0	12.8	11.9	13.7	22.0
El Salvador	10.7	11.5 i/	12.8	...	14.8 i/	14.9
Ecuador	(7.5)	(11.2)	(6.4)	...	...	(5.6)
Guatemala	8.7	8.8 i/	10.2	9.3	9.2 i/	10.9
Paraguay	8.4	8.9	8.0	9.4	10.3	9.0
Honduras	4.5	6.2 i/	3.0	...	13.9 i/	15.0
Haiti	...	...	...	...	...	20.8
Latin America	7.9	9.1	10.1	7.3 j/	8.9 k/	10.4

Sources: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.

a/ Estimates for 1959. Exceptions are El Salvador, Chile, Colombia, Paraguay, Uruguay, Venezuela (in the case of the public service only), Costa Rica, Cuba, Guatemala, Honduras, Mexico, Nicaragua, Panama and Surinam.

b/ See table 15, footnote a/

c/ In the case of hydraulic generation, data could be obtained only from the Cía. Cubana de Electricidad and to Hernández y Hno. (Pinar del Río).

d/ 1948-59.

e/ Excluding the Canal Zone for want of information.

f/ 1940-59.

g/ 1952-59.

h/ 1954-59.

i/ 1950-59.

j/ Excluding Brazil, Ecuador, Costa Rica, Haiti, El Salvador, Honduras, Nicaragua and the West Indies.

k/ Excluding Brazil, Ecuador and Haiti.

/(a) After

(a) After 1955 there was a general weakening of the international markets for many Latin American exports; the effects of this were enhanced by the economic recession that began in the United States at the end of 1956;

(b) The limited amount of internal resources available for financing electric power installations, which has recently become a more acute problem in a good many countries;

(c) The lack of sufficient foreign exchange to import the necessary materials and equipment;

(d) The drastic measures taken by certain Governments during the same period to curb inflation. These measures had a restraining effect on public investment and on various branches of activity and reduced the latter's electric power consumption.

In 1949-59, the rate of growth for the public services was higher than that for total generation in every Latin American country with the exception of Argentina, where total production increased at the rate of 7.1 yearly and that of the public utility at 6.2 per cent, much smaller differences being recorded in Colombia, Mexico and Panama as well (see again table 17). This demonstrates that the public services were much more dynamic than those generating electricity for private use.

In the first group, an average rate of growth of more than 10.5 per cent yearly (duplication in seven years, which corresponds to the world average in the last decade) was registered since 1949 in Venezuela and Cuba only.

In the second group, all the countries show an annual rate of more than 10.5 per cent in 1949-59 or 1955-59, with the exception of Mexico and Costa Rica. Peru is notable for its high and sustained rate of growth of over 11 per cent annually, which, among other reasons connected with its overall economic development, must be attributed to the fact that the Government has been taking an active interest in the electricity service, which culminated in the promulgation of the Electricity Industry Act of 5 January 1956. From 1955 to 1959, Brazil attained an average rate of 11.9 per cent. This reflects the development of the numerous public services which can count on the participation or collaboration or the State authorities and/or Federal Government.

/In the

In the third group, the Dominican Republic, British Guiana, Nicaragua, El Salvador and Honduras maintained a growth rate of over 10.5 per cent in the last decade. The difficulties besetting the supply of electricity in El Salvador were largely remedied in 1954 with the entry into operation of the first plant of the Comisión Hidroeléctrica del río Lempa, which, in 1958, provided nearly 73 per cent of the energy generated by the public service.

3. Sources of energy

Although the contribution of water resources to Latin America's total electricity production remained virtually the same, a slight rise only being noted in the last four years (53.0 per cent in 1959), in the case of the public services it increased from 43.4 in 1938 to 55.4 in 1955 and 60.9 per cent in 1959.

Nevertheless, very little use is made of water for this purpose. It is estimated that if the relevant demand materialized, it would be possible to install a capacity of some 150 million kW on known economically-exploitable sites throughout Latin America. Not even 4.5 per cent of this potential was used in 1959 (Hydroelectric resources in Latin America; their measurement and utilization (ST/ECLA/CONF.7/L.3.0)). In absolute terms, the major producer of hydroelectricity in 1959 was Brazil with 17,900 million kWh. Next came Mexico, Chile and Colombia with 5,900, 2,900 and 2,200 million kWh respectively. These four countries together provide 88 per cent of the total amount of hydraulic energy generated in Latin America (see table 18).

The countries in which hydroelectricity accounted for the largest part of the public service supply in 1959 were El Salvador, Bolivia, Chile, Costa Rica and Brazil, with proportions ranging from 99.6 per cent for the first-named to 86.0 per cent for the last. Conversely, up to that year hydroelectric production did not reach significant proportions in Cuba, Haiti, Paraguay, the Dominican Republic and Surinam (see table 19). 4/

4/ The share of hydroelectricity in the total production of some European countries in 1959 was as follows (in percentage terms): Norway 99, Switzerland 99, Sweden 90, Portugal 96, Finland 70, Italy 78, Austria 74, Spain 83, Yugoslavia 60, France 51 and the USSR 19 (ST/ECE/EP/9, op.cit.). In the United States it was 18 per cent.

Table 18

LATIN AMERICA: HYDRAULIC GENERATION a/

(Millions of kWh)

Country	Public service				Public and private			
	1938	1949	1955	1959	1938	1949	1955	1959
First group								
Venezuela	(34)	134	181	100	(34)	(134)	(181)	(100)
Chile	(560)	891	1 588	2 158	740	1 564	2 328	2 929
Argentina	84	159	316	640	84	159	316	640
Uruguay	-	485	678	760 b/	-	485	678	760 b/
Cuba c/	(7)	13	14	7	(7)	13	14	7
Second group								
Costa Rica	...	158	232	334	(55)	(172)	(251)	(347)
Brazil	...	...	9 785	16 869	(2 500)	6 765	10 605	17 869
Mexico	(1 600)	(2 013)	(3 276)	5 707	1 871	2 085	3 447	5 900
Surinam	-	-	-	-	-	-	-	-
West Indies	...	25	80	(86)	...	(25)	80	(86)
Colombia	(176)	710	1 400	(2 126)	206	760	1 480	(2 236)
Panama	...	...	...	16 d/	...	...	...	16
Peru	283 e/	428 f/	491 g/	(780)	523	888	1 009	(1 358)
Third group								
British Guiana	-	-	-	-	-	-	-	-
Bolivia	62	161	212	(270)	152	269	334	(375)
Nicaragua	...	2 h/	2	3	...	(31)	(36)	(39)
Dominican Republic	-	-	-	-	-	-	-	-
El Salvador	...	38 h/	128	227	(24)	(38)	(128)	227
Ecuador	...	...	106	(135)	57	(82)	120	(161)
Guatemala	31	71 h/	100	106	(31)	(71)	(100)	(106)
Paraguay	-	-	-	-	-	-	-	-
Honduras	...	4 h/	5	12	...	(4)	(5)	(12)
Haiti	-	-	-	-	-	-	-	-
Latin America	2 937 i/	2 292 j/	18 594 k/	30 336	6 284 l/	13 545	21 111 m/	33 168

Sources: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.

a/ Further information in Statistical Annex C.

b/ See table 15, footnote a/

c/ In the case of hydraulic generation, data could be obtained only from the Cía. Cubana de Electricidad and Hernández y Hno. (Pinar del Río).

d/ Excluding the Canal Zone for want of information.

e/ 1940.

f/ 1952.

g/ 1954.

h/ 1950.

i/ Excluding Brazil, Ecuador, Costa Rica, El Salvador, Honduras, Nicaragua, Panama and the West Indies.

j/ Excluding Brazil and Panama.

k/ Excluding Panama.

l/ Excluding Honduras, Nicaragua, Panama and the West Indies.

m/ Excluding Panama.

/Table 19

Table 19

LATIN AMERICA: SHARE OF HYDROELECTRICITY IN GENERATION BY THE PUBLIC SERVICE AND BY PUBLIC AND PRIVATE PLANTS a/

(Percentages)

Country	Public service				Public and private			
	1938	1949	1955	1959	1938	1949	1955	1959
First group								
Venezuela	(30.4)	29.5	14.2	3.7	(14.3)	13.3	7.6	2.3
Chile	(87.6)	87.1	85.7	95.5	45.3	54.4	60.5	63.7
Argentina	3.6	3.7	5.4	8.3	3.1	3.2	4.6	6.5
Uruguay	-	84.6	66.3	61.5 b/	-	84.6	66.3	61.5b/
Cuba c/	(21.6)	17.2	10.6	3.4	(13.4)	10.9	7.6	2.5
Second group								
Costa Rica	...	100.0	87.5	92.8	64.7	94.5	84.8	90.6
Brasil	...	...	78.1	86.0	83.7	88.9	77.7	84.7
Mexico	(75.5)	(57.3)	(58.3)	72.3	74.5	48.2	49.2	60.2
Surinam	-	-	-	-	-	-	-	-
West Indies	...	26.0d/	31.4	19.8	...	10.1	19.3	13.6
Colombia	(59.9)	76.3	76.9	78.8	61.7	67.3	65.8	66.8
Panamá	...	...	...	7.9	...	...	...	7.0
Peru	90.1e/	92.8f/	86.7g/	80.3	82.1e/	84.6f/	74.0g/	61.4
Third group								
British Guiana	-	-	-	-	-	-	-	1.4
Bolivia	96.9	97.6	98.1	96.1	80.4	83.8	86.3	88.0
Nicaragua	...	8.3h/	4.2	3.2	...	34.8h/	29.0	22.4
Dominican Rpublic	-	-	-	-	-	-	-	-
El Salvador	...	57.6h/	97.7	99.6	...	43.2h/	88.3	96.6
Ecuador	...	...	49.5	50.8	80.3	71.3	46.3	48.5
Guatemala	100.0	78.0h/	75.2	52.7	(73.8)	62.3h/	60.6	43.6
Pareguay	-	-	-	-	-	-	-	-
Honduras	...	30.8h/	20.8	28.6	...	8.0h/	(8.2)	(14.0)
Haiti	-	-	-	-	-	-	-	-
Latin America	43.4	41.5	55.4	60.9	50.1	51.4	49.6	53.0

Source: Direct information and ECLA publications.
Note: The figures in brackets are ECLA estimates.

a/ Further information in Statistical Annex C.
b/ See table 15, footnote a/
c/ In the case of hydraulic generation, the data could be obtained only from the Cia. Cubana de Electricidad and Hernández y Hno (Pinar del Río).
d/ 1948.
e/ 1940.
f/ 1952.
g/ 1954.
h/ 1950.

/The participation

The participation of water resources in electricity generation has increased appreciably in some countries, particularly in the course of the last decade. For instance, in Uruguay, nearly all the electricity produced before 1945 was of thermal origin. After the hydro plant, Rincón del Bonete, had entered into operation at the end of 1945, however, hydroelectricity replaced thermoelectricity, accounting for about 85 per cent of total generation in 1949. Thereafter its share decreased (reaching 61.5 per cent in 1958), but will increase again once the new Rincón de Baygorría plant starts operations.5/ The decline of hydroelectric generation in 1959 was brought about by the big floods that occurred in that year and put the Rincón del Bonete plant out of action for several months.

In Argentina, hydroelectric production more than doubled its share in the last twenty years, but is still very small (6.5 per cent of total generation in 1959).

In El Salvador, as indicated before, the construction of the 5 de Noviembre plant on the river Lempa raised the contribution of hydroelectricity in the public sector from 41 per cent in 1953 to over 98 per cent in 1956.

In Chile and Colombia, where hydraulic generation has played a decisive part in electricity development, its share of total production has continued to expand during the last twenty years.

In Honduras, the contribution of hydroelectricity is increasing but is still at a very low level.

In other countries, however, such as Venezuela, Costa Rica, Mexico, and Nicaragua hydroelectricity has been losing ground within total generation.

5/ At the end of 1960 the plant entered into operation with the use of its full capacity of 98 MW.

In Venezuela, the fact that the decline in the contribution of hydraulic energy became more pronounced in 1949-59 (from 30.4 to 3.7 per cent of production in the public sector) may be attributed to the substantial increase in thermal production on the basis of petroleum and its derivatives. However, if the Macagua power station of 300,000 kW on the river Caroní, which has already been completed, is actually in operation in 1961 with the final plant factor as contemplated in the project, the 1949 level of 30 per cent will be recovered.

Table 20 shows that hydroelectric generation is developing with increasing speed in Latin America, since the rates for the public electricity services were 7.0, 9.3 and 12.6 per cent in the periods 1938-59, 1949-59 and 1955-59 respectively. There are hopes that its proportion will continue to expand in the next few years, since most of the countries have specific projects and plans - some already under way - for developing their water resources, not only for energy production, (as will be seen in chapter IV), but on an integrated multi-purpose basis.

With respect to thermal generation, the same trend is followed in Latin America as that observed previously in more developed countries. Internal combustion engines are gradually becoming less important and are mainly to be found in power stations belonging to the public utility in small urban centres where, because demand is small, they are far from hydroelectric resources or water for steam generation is in short supply, there are almost no other possibilities to choose from. Nevertheless, a great many diesel power stations have been set up as a quick and temporary solution to the problem and, as an emergency measure, in towns that have neglected to programme and expand their electricity services. In the self-supplying sector, and manufacturing industry in particular, internal combustion engines are used intensively in areas that are outside the scope of the public service or as an emergency measure when the public electricity supply is inadequate. Table 21 shows the respective participation of steam turbines and internal combustion engines in thermoelectricity generation for public use. In Bolivia, El Salvador and Honduras thermal generation for the

/ Table 20

Table 20

LATIN AMERICA: ANNUAL RATE OF GROWTH OF PUBLIC UTILITY GENERATION

(Percentages)

Country	Hydroelectricity			Thermoelectricity		
	1938-59	1949-59	1955-59	1938-59	1949-59	1955-59
First group						
Venezuela	5.3	-2.9	-13.8	18.2	23.4	24.4
Chile	7.8	9.2	8.0	1.2	-2.6	-21.2
Argentina	10.2	14.9	19.3	5.7	5.7	6.2
Uruguay	-	+5.1 a/	+3.8 a/	3.6 a/	20.6 a/	11.4 a/
Cuba b/	0	-6.0	-15.9	9.3	10.8	12.1
Second group						
Costa Rica	...	7.7	9.5	...	-	-5.6
Brazil	...	...	14.6	...	...	0.1
Mexico	6.2	11.0	14.9	7.1	3.9	-1.6
Surinam	-	-	-	9.0	15.3 c/	7.5
West Indies	...	11.9 d/	1.8	...	15.5 c/	18.8
Colombia	12.6	11.6	11.0	7.8	10.0	8.0
Panama d/	-	-	-	9.1	9.6	13.2
Peru	5.5 e/	9.0 f/	9.7 g/	10.0 e/	28.5 f/	20.6 g/
Third group						
British Guiana	-	-	-	6.9	13.3	12.1
Bolivia	7.3	5.3	6.2	8.5	10.6	28.8
Nicaragua	...	4.6 h/	10.7	...	17.1 h/	18.6
Dominican Republic	-	-	-	12.0	13.7	22.0
El Salvador	...	-22.0 h/	15.4	...	-30.9 h/	-24.0
Ecuador	...	...	6.4	...	...	4.7
Guatemala	6.3	4.6 h/	1.5	-	18.9 h/	30.3
Paraguay	-	-	-	9.4	10.3	9.0
Honduras	...	13.0 h/	19.1	...	14.3 h/	12.1
Haiti	-	-	-	...	...	20.8
Latin America	7.2 i/	9.7 j/	13.0	7.5 i/	8.3 j/	6.8

Sources: Direct information and ECLA publications.

a/ See table 15, footnote a/.
b/ In the case of hydraulic generation, data could be obtained only from the Cia. Cubana de Electricidad and Hernández y Hno. (Pinar del Río).
c/ 1948-59.
d/ Excluding the Canal Zone for want of information.
e/ 1940-59.
f/ 1952-59.
g/ 1954-59.
h/ 1950-59.
i/ Excluding Brazil, Ecuador, Costa Rica, Haiti, El Salvador, Honduras, Nicaragua and the West Indies.
j/ Excluding Brazil and Ecuador.

/Table 21

Table 21

LATIN AMERICA: THERMAL GENERATION BY THE PUBLIC SERVICE

(Percentages)

Country	Steam				Internal combustion			
	1938	1949	1955	1959	1938	1949	1955	1959
First group								
Chile	...	...	...	47.1	...	...	...	52.9
Argentina	...	...	85.0	(86.6)	...	...	15.0	(13.4)
Uruguay	92.3	29.5	73.0	91.4	7.7	70.5	27.0	8.6
Second group								
Costa Rica	...	...	97.0	19.2	...	...	3.0	80.8
Panama	100.0	100.0	100.0	90.4	-	-	-	9.6
Peru	3.2a/	3.0b/	45.3c/	...	96.8a/	97.0b/	54.7c/	...
Third group								
Bolivia	-	-	-	-	100.0	100.0	100.0	100.0
Nicaragua	...	4.5d/	2.2	86.8	...	95.5d/	97.8	13.2
El Salvador	...	78.6d/	30.3	-	...	21.4d/	66.7	100.0
Guatemala	-	85.0d/	84.8	69.5	-	15.0d/	15.2	30.5
Paraguay	100.0	100.0	100.0	100.0	-	-	-	-
Honduras	-	-	-	-	...	100.0	100.0	100.0

Source: Direct information and ECLA publications.

Note: The figures in brackets are ECLA estimates.

a/ 1940.

b/ 1952.

c/ 1954.

d/ 1950.

public utilities is entirely on the basis of diesel engines. In Argentina, Uruguay, Nicaragua and Panama the share of this type of generation ranges from 5 to 15 per cent, and, except in Panama, has shown a downward trend in the last few years.

Some gas turbine plants exist in Venezuela, Peru and Ecuador, with less than 150,000 kW total capacity [6/]; in the first and last of these countries they are connected with petroleum extraction. In the tables belonging to this document, this type of power station has been included among internal combustion plants.

4. Fuel consumption in thermal generation

(a) Specific consumption

No satisfactory data are available on fuel consumption for electricity generation in the different Latin American countries. An incomplete analysis, which should be considered as no more than a provisional estimate of yield in relation to thermoelectric generation, gave rise to the following main conclusions:

(i) Fuel consumption per kWh generated varies considerably, ranging from the high figure of 0.74 kilogrammes of petroleum equivalent for a public service plant of 17 megawatts, fuelled mainly by wood (100,000 tons of wood plus 16,000 tons of fuel-oil to generate 66,000 kWh) to a little under 0.25 kilogrammes in numerous diesel plants and some big modern steam stations. None the less, the high values predominate and in some cases are almost twice as much as the amount consumed in countries that are technically

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6/ In Venezuela, 45 MW corresponding to public utilities and 93 MW corresponding to private plants; three other projects exist which total 55 MW. In Peru, 10 MW (the installation of a plant with 20 MW is well under way) corresponding to public utilities, and in Ecuador, 3.3 MW corresponding to private plants.

more advanced (see tables 22 and 23);[7]

(ii) On the whole, improvement is slow and in some cases there has even been a falling-off;

(iii) The regional average would be about 0.40 to 0.42 kilogrammes of petroleum equivalent per kWh, given that during the Second World War and the early years of recovery it was 0.48 kg/kWh.

(b) Annual consumption

In order to study fuel consumption for electricity production by countries and to determine its proportion of total consumption in those countries, the estimates made were based on thermal generation and on yields calculated for more or less representative samples (see table 24).

In 1959, fuel consumption for electricity generation was 11.8 million tons of petroleum equivalent, Argentina, Mexico, Venezuela and Brazil accounting for nearly 70 per cent of the regional total.

Consumption increased at the average cumulative rate of 6.9, 7.2 and 7.9 per cent annually in 1938-59, 1949-59 and 1955-59, respectively. The greatest development took place in Venezuela, Peru and Guatemala.

Of the total amount of commercial fuel consumed in Latin America, electricity production accounts for 17.3 per cent. This proportion has remained practically the same for the last 20 years (see table 25). Nevertheless, it should be noted that in such countries as Paraguay, Haiti, the Dominican Republic, Nicaragua and Cuba, where thermo-electric generation carries most weight within the total consumption

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7/ Average consumption in the United States was 0.261 kg of petroleum equivalent (2,790 Kcal) per kWh generated (see Edison Electric Institute, Electric Utility Industry Statistics in the United States, 1958). In some European countries, the amount of fuel consumed by public service plants in 1956 to generate 1 kWh (in kilogrammes of petroleum equivalent) was Austria 0.349, Belgium 0.330, Federal Republic of Germany 0.335, France 0.336, Greece 0.385, United Kingdom 0.324 (ECLA, on the basis of information in OEEC, L'Evolution du prix de vente de l'électricité. In Asia, the corresponding figures for 1958 were India 0.49, Indonesia 0.80, Japan 0.38, South Korea 0.49, Taiwan 0.43 (ECLA, on the basis of information in Electric power in Asia and the Far East, 1958, (ECAFE/SER.L/6)).

/Table 22

Table 22

LATIN AMERICA: GENERATING YIELDS IN PUBLIC UTILITY THERMAL PLANTS IN SELECTED COUNTRIES

(Tons of petroleum equivalent per 1 000 kWh generated)

Country	1940	1948	1951	1955	1956	1958
Argentina a/	0.37	0.42	0.38	0.37	0.38	0.35
Chile a/		0.41 b/		0.50	0.53	0.52 c/
Mexico	0.46	0.49	0.38			
Uruguay	0.43	0.53	0.38	0.38		
Paraguay	0.72 d/	0.67		0.71		0.74
Peru	0.73	0.58				
Venezuela a/		0.41	0.38	0.35	0.40	0.35

Source: ECLA, on the basis of direct information
a/ Country average.
b/ 1949.
c/ 1957.
d/ 1942.

Table 23

LATIN AMERICA: GENERATING YIELDS IN SELECTED PUBLIC UTILITY PLANTS (ELECTRIC BOND & SHARE CO.)

(Tons of petroleum equivalent per 1 000 kWh generated)

Country	1948	1955
Brazil	0.62	0.44
Cuba b/	0.50	0.42
Colombia c/	0.41	0.38
Chile d/	0.59	0.44
Mexico e/	0.50	0.49

Source: ECLA, on the basis of information from the Ebasco International Corporation.
a/ Data for 8 power stations, with 79 220 kVA in all.
b/ Data for 7 power stations, with 192 000 kVA in all.
c/ Data for 3 power stations with 26 096 kVA in all.
d/ Data for 3 power stations with 59 470 kVA in all.
e/ Data for 9 power stations with 112 690 kVA in all.

/Table 24

Table 24

LATIN AMERICA: FUEL CONSUMPTION IN ELECTRICITY GENERATION AND ANNUAL RATE OF GROWTH a/

Country	Thousands of tons				Rate of growth (Percentage)	
	1938	1949	1955	1959	1938-59	1955-59
First group						
Venezuela	97	360	772	1 474	13.9	17.6
Chile	581	775	668	734	1.1	1.9
Argentina	998	2 024	2 400	3 304	5.9	8.3
Uruguay	101	47	138	190 b/	3.1 b/	11.3 b/
Cuba	174	403	600	865	7.9	9.5
Second group						
Costa Rica	5	7 c/	22	15	5.4	-9.9
Brazil	292	524	1 342	1 415	7.8	1.2
Mexico	340	1 122	1 742	1 911	8.6	2.3
Surinam	5	12	18	28	8.6	11.7
West Indies	44	105	140	224	8.1	12.5
Colombia	68	152	293	423	9.1	9.6
Panama	16	35	60	89	8.5	10.3
Peru	83 d/	118 e/	205 f/	495	9.9	19.3
Third group						
British Guiana	15	16	23	32	3.7	8.6
Bolivia	13	18	19	18	1.6	-1.4
Nicaragua	21	25 c/	31	52	7.2	13.8
Dominican Republic	13	33	82	128	11.5	11.8
El Salvador	2	21 c/	6	3	1.9	-15.9
Ecuador	5	12	49	60	12.6	5.2
Guatemala	6	20 c/	27	55	11.1	19.5
Paraguay	12	24	45	62	8.1	8.3
Honduras	18	22 c/	24	31	2.6	6.6
Haiti	11	16	25	38	6.1	11.0
Latin America	2 920	5 891	8 731	11 646	6.8	7.5

Sources: Direct information and ECLA publications.

a/ Further information in Statistical Annex C.

b/ 1958. See table 15, footnote a/

c/ 1950.

d/ 1940.

e/ 1952.

f/ 1954.

/Table 25

Table 25

LATIN AMERICA: SHARE OF THERMOELECTRIC GENERATION IN COMMERCIAL FUEL CONSUMPTION a/

(Percentages)

Country	1938	1949	1955	1959
First group				
Venezuela	17.4	9.9	10.1	14.4
Chile	29.3	31.1	18.8	21.1
Argentina	15.8	24.2	19.9	24.6
Uruguay	18.1	6.0	12.5	15.7 b/
Cuba	21.9	24.2	24.0	27.1
Second group				
Costa Rica	12.8	7.3 c/	19.5	9.4
Brazil	9.7	10.7	13.5	10.3
Mexico	11.8	14.7	18.0	14.4
Surinam	26.3	15.6	18.8	24.8
West Indies	16.7	20.7	18.7	27.6
Colombia	10.5	9.6	9.2	10.6
Panama	50.0	22.2	20.6	26.3
Peru	14.5 d/	7.9 e/	12.2 f/	25.5
Third group				
British Guiana	50.0	14.2	14.4	21.3
Bolivia	19.1	12.5	7.6	6.8
Nicaragua	95.5	36.7	24.2	24.5
Dominican Republic	24.1	30.8	30.8	36.8
El Salvador	7.1	23.1 c/	4.0	1.5
Ecuador	10.0	5.6	14.1	14.9
Guatemala	7.2	7.3 c/	8.5	13.6
Paraguay	...	...	77.5	71.3
Honduras	16.1	15.2 c/	17.9	15.0
Haiti	100.0	88.9	32.9	40.0
Latin America	16.1	17.1	16.0	17.3

Sources: Direct information and ECLA publications.

a/ Further information in Statistical Annex C.

b/ See table 15, footnote a/

c/ 1950.

d/ 1940.

e/ 1952.

f/ 1954.

/of commercial

of commercial fuel, the relevant figures are not an accurate reflection of the situation, as they are in the remaining cases. In fact, firewood and bagasse, which are not included among commercial fuels, are used to a substantial extent in electricity production.

For instance, in Paraguay (where the discrepancy is largest), nearly 65 per cent of the heat utilized in the power stations came from firewood in 1958 (in 1959 it dropped to 55 per cent). As a result, the share of thermoelectric generation in total commercial fuel consumption would shrink to less than 25 per cent from 64 per cent in 1958 and in 1959, would decrease from 71.3 to 39 per cent. In the case of Cuba, the difference is much less, the share of thermoelectric generation in 1959 contracting from 27.1 to 15 per cent. In the other countries, the figures are closer to reality.

In Chile, Argentina, Surinam, Peru, British Guiana and Nicaragua, thermoelectric production in 1959 constituted a similar proportion of total fuel consumption with figures ranging from 21 to 26 per cent. In most of these countries, the proportion showed a slight tendency to expand.

In Venezuela, Brazil, Mexico, Colombia, Ecuador, Guatemala and Honduras, thermoelectric production in 1959 represented from 10 to 15 per cent in every case, with very slight variations during the course of the year.

In respect to electricity development in Chile, Costa Rica, Peru and Uruguay, it should be noted that a large proportion of the energy generated is hydraulic in origin, and that these countries form part of the group whose fuel consumption for electricity production is the same or greater than the regional average.

(c) Types of fuel

If vegetable fuels are excluded, petroleum derivatives (fuel-oil, diesel-oil and gas-oil) may well constitute more than 80 per cent of the total amount used in electricity information, although the information on this point is very fragmentary. These fuels are followed in order of importance by coal, which is chiefly used in Colombia, Argentina, Mexico and Chile. Firewood and plant residues, which are important sources of

fuel for electricity generation in certain countries - principally Paraguay (60 per cent on an average), Cuba (30 per cent on an average), Haiti and the Dominican Republic - are of no importance in Latin America as a whole.

In the petroleum-producing countries - Venezuela, Mexico, Colombia and Argentina - natural gas, which, years ago, was merely used on a small scale for electricity generation within the petroleum industry itself, is now beginning to acquire considerable importance.

Owing to the lack of information, it is impossible to make detailed table of the types of fuel used in electricity production by countries. Hence, the picture of the situation in table 26 is necessarily incomplete.

(d) Imports

Although Latin America is a net exporter of fuel, with Venezuela, Mexico and Colombia heading the list of petroleum exporters, fuel imports are a weighty item in the other countries' external balance of payments. This is the situation in Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti Honduras, Nicaragua, Panama, Paraguay, Surinam and Uruguay which import all or nearly all the fuel that they require (see Statistical Annex F).

In these countries, consumption of fuels for thermoelectric production has the same relationship to the quantity imported (in percentage terms) as to total consumption.

In Argentina and Brazil as well, fuels form a substantial part of total imports, amounting to 48 and 14.5 per cent respectively (the favourable effect of Argentina's plans to increase its petroleum production being apparent from 1959 onwards). These figures are merely an indication, since part of the fuel actually used in electricity generation is obtained locally. In Chile, fuel imports decreased from 1956 onwards, and are now confined to the requirements of the big mining companies.

Statistical Annex E gives a general picture of production and consumption of the different types of commercial fuel by countries during the last two decades.

/Table 26

Table 26

LATIN AMERICA: DETAILS OF FUEL CONSUMPTION IN ELECTRICITY PRODUCTION IN SELECTED COUNTRIES

(Thousands of tons of petroleum equivalent)

Country		Coal	Fuel-oil	Diesel-oil	Natural gas	Firewood and other	Remarks
Argentina	(1958)	207	1 970	232	8	4	Public utility
Chile	(1957)	123	← 616 →				
Venezuela	(1957)		276	24	308		"
Paraguay	(1958)		12			72	
Dominican Republic	(1958)		90	3		...	"

Chapter IV

INSTALLED CAPACITY IN LATIN AMERICA

1. Public utilities and self-suppliers

It was seen in Chapter III that the situation in the public utilities during the second world war led to a temporary increase in self-supply, on the basis of a large number of generating plants of low capacity. Light groups, with motive power supplied by medium and high revolution internal combustion engines constituted a high proportion of the generating capacity thus installed, including in some cases units designed for the use of the armed forces. Generating costs were high, among other reasons because of low utilization factors, lack of trained staff for proper operating and maintenance, the need for rapid amortization (because of the very nature of the equipment), difficulties in supplying spare parts for such a varied collection of generating equipment, etc.

Furthermore, the importing of all this machinery reduced the availability of foreign exchange for the acquisition of other capital goods required by industry, including the electricity industry supplying power for the public utilities.

When the supply of materials and equipment, manufactured in accordance with the specific requirements of each plant for the generation and distribution of electricity, was regularized, the public service enterprises, as was to be expected, invested large sums in repairs, expansion and the construction of new systems.[1/] Nevertheless, these efforts were usually not sufficient to meet the whole of the unsatisfied demand (that had grown up during the war) together with the additional demand resulting from the expansion of economic activity that then took place.

It was largely in this way that the imbalance between supply and demand in electricity grew up, and still persists in a number of countries as a chronic condition, mainly as a result of lack of funds, aggravated in some cases by lack of foresight.

1/ The estimated total of these investments for the whole of Latin America during 1945-49 amounts to some 500 million dollars.

/In many

In many cases governments, much exercised by this problem, during the forties and early fifties established various bodies for the purpose of planning the development of the supply of electricity, operating supply systems and acting as the channel for the investment of domestic public funds and the obtaining of foreign loans (see table 27). At the end of 1959 such bodies represented 45 per cent of such public service capacity, and this share rose to about 60 per cent at the end of 1960. Up to that year, loans granted by the International Bank for Reconstruction and Development (IBRD) and the Export-Import Bank (Eximbank) alone for the purpose of electricity development in the region exceeded 900 million dollars.

Although most of these bodies took firm action from the outset with respect to production, they were less active in the field of distribution and in some cases left this work in the hands of private enterprise. However, in the course of time the idea gained ground that this service should increasingly be managed by public bodies.

For the region as a whole, total installed capacity at the end of 1959 amounted to 16.1 million kW, of which the public utilities represented 12.3 million. The corresponding per capita figures were 82 W and 63 W, respectively (see table 28).

Table 29 ranks countries according to their installed capacity in 1959, within the previously established groups. It will be noted that the position of some countries is different from that in the previous listing (see table 30) because of the different degree of utilization of their equipment, as will be seen below.

The rate of increase in installed capacity for the whole region has increased, the annual growth rates in the public utilities for the periods 1938-59, 1949-59 and 1955-59 being 5.4 per cent, 8.4 per cent and 9.8 per cent respectively (see tables 30 and 31).

In the three years that preceded 1960 the increase in the installed capacity in the public utilities exceeded the increase in the demand, with very few exceptions. Consequently the interruption in the growth of consumption noted in the previous chapter enabled electricity enterprises

/Table 27

Table 27

OFFICIAL INSTITUTIONS FOR THE DEVELOPMENT OF THE ELECTRICITY SERVICES ORGANIZED BETWEEN 1940 AND 1955*

Country	Year	Name of enterprise
Argentina	1947	Agua y Energía Eléctrica
Brazil	1948	Compañía Eléctrica de San Francisco (CHESF)
Brazil	1952	Centrais Elétricas de Minas Gerais, S.A.(CEMIG)
Brazil	1952	Comisión Estatal de Energía Eléctrica (CEEE)
Brazil	1955	Compañía Hidroeléctrica Río Pardo (CHERP)
Brazil	1953	Compañía Hidroeléctrica Paranapanema (USELPA)
Colombia	1946	Instituto de Aprovechamiento de Aguas y Fomento Eléctrico.
Costa Rica	1949	Instituto Costarricense de Electricidad.
Chile	1943	Empresa Nacional de Electricidad, S.A.(ENDESA) a/
El Salvador	1945	Comisión Ejecutiva Hidroeléctrica del Río Lempa.
Mexico	1949	Comisión Federal de Electricidad (CFE) (reorganización) b/
Paraguay	1948	Administración Nacional de Electricidad (ANDE)
Panama	1954	Servicio Cooperativo Interamericano de Fomento Económico (SCIFE) c/
Venezuela	1948	Corporación Venezolana de Fomento d/

Source: ECLA, on the basis of direct information and various publications.

* A complete list of all the national and state institutions responsible for electricity development in Latin America and their functions is given in the Annex.

a/ This body is responsible for the execution of the National Electrification Plan initiated by the Corporación de Fomento de la Producción (1940).

b/ This institution was first founded in 1939.

c/ Receives assistance from the United States and is concerned among other things with the country's electricity development.

d/ This institution's responsibilities originally included the execution of the National Electrification Plan, which subsequently (1959) passed to CADAFE (Compañía Anónima de Administración y Fomento Electrico).

/Table 28

Table 28

LATIN AMERICA: INSTALLED CAPACITY IN 1959

Country	Population (Thousands)	For the whole sector		For the public service		
		Thousands of kW	Watts per capita	Thousands of kW	Percentage of total	Watts per capita
Argentina	20 708	3 029	(146)	2 370	78	114
Bolivia	3 383	(111)	(33)	(79)	71	(23)
Brasil	64 568	4 115	64	3 747	91	58
Chile	7 372	1 091	148	596	55	81
Colombia	13 950	(865)	(62)	635	73	(46)
Ecuador	4 128	(110)	(27)	(87)	79	(21)
Paraguay	1 716	30	17	24	80	(14)
Peru	10 524	(718)	(68)	(320)	45	(30)
Uruguay	2 787	332	119	332	100	119
Venezuela	6 505	1 277	196	857	67	132
Costa Rica	1 084	110	101	100	91	91
Cuba	6 662	932	140	545	58	82
El Salvador	2 490	(74)	(30)	65	88	26
Guatemala	3 677	(73)	(20)	60	82	16
Haiti	3 653	...	...	(13)	...	(4)
Honduras	1 872	(31)	(17)	16	52	9
Mexico	33 229	2 739	82	2 118	79	64
Nicaragua	1 414	(75)	(53)	47	63	33
Panama	1 012	(60)	(59)	50	83	49
Dominican Republic	2 760	(98)	(36)	(88)	(90)	(32)
British Guiana	549	(41)	(75)	(16)	39	(29)
West Indies a/	2 488	(175)	(70)	(126)	72	(51)
Surinam	255	27	106	13	48	51
Latin America	196 786	16 113	82	12 304	76	63

Source: ECLA, on the basis of direct information and various publications.
Note: The figures in brackets are estimates by ECLA.

a/ Trinidad, Tobago and Jamaica.

/Table 29

Table 29

LATIN AMERICA: PER CAPITA INSTALLED CAPACITY BY TYPE OF SERVICE, 1959

(Watts per capita)

Country	Total	Public service	Private service
First group			
Venezuela	196	132	64
Chile	148	81	67
Argentina	(146)	114	32
Cuba	140	82	58
Uruguay	119	119	-
Second group			
Surinam	106	51	55
Costa Rica	101	91	10
Mexico	82	64	18
West Indies a/	(70)	(51)	(19)
Peru	(68)	(30)	(38)
Colombia	(62)	(46)	(16)
Brazil	64	58	6
Panama	(59)	49	(10)
Third group			
British Guiana	(75)	(29)	(46)
Nicaragua	(53)	33	(20)
Dominican Republic	(36)	(32)	(4)
Bolivia	(33)	(23)	(10)
El Salvador	(30)	26	(4)
Ecuador	(27)	(21)	(6)
Guatemala	(20)	16	(4)
Honduras	(17)	9	(8)
Paraguay	17	14	3
Haiti	...	(4)	...
Latin America	82	63	19

Source: ECLA, on the basis of direct information and various publications.

Note: The figures in brackets are estimates by ECLA.

a/ Trinidad, Tobago and Jamaica.

/Table 30

Table 30

LATIN AMERICA: GROWTH OF INSTALLED CAPACITY IN THE PUBLIC SERVICE a/

(Thousands of kW)

Country	1938	1949	1955	1959
First group				
Venezuela	...	140	405	857
Chile	(165)	356	538	596
Argentina	1 177	1 344	1 619	2 370
Cuba	122	177	324	545
Uruguay	102	221	285	332
Second group				
Surinam	...	...	8	13
Costa Rica	15	37 b/	51	100
Mexico	474	831	1 480	2 118
West Indies c/	...	36 d/	95	(126)
Peru	104 e/	158 f/	174 g/	(320)
Colombia	...	...	...	(635)
Brazil	1 206 e/	1 652	2 980	3 747
Panama h/	10	21	38	50
Third group				
British Guiana	...	...	13	(16)
Nicaragua	...	8 b/	16	47
Dominican Republic	...	...	60	(88)
Bolivia	19	41	55	(79)
El Salvador	...	18	51	65
Ecuador	...	...	46	(87)
Guatemala	...	27 b/	32	60
Honduras	...	4 b/	7	16
Paraguay	4	10	18	24
Haiti	...	...	12	(13)
Latin America	3 398 i/	5 081 j/	8 308 k/	12 304

Source: ECLA, on the basis of direct information and various publications.
Note: The figures in brackets are estimates by ECLA.

a/ Further information is given in statistical annex G.
b/ 1950.
c/ Trinidad, Tobago and Jamaica.
d/ 1948.
e/ 1940.
f/ 1952.
g/ 1954.
h/ Excluding the Canal Zone.
i/ Excluding Venezuela, Surinam, West Indies, Colombia, British Guiana, Nicaragua, Dominican Republic, El Salvador, Ecuador, Guatemala, Honduras and Haiti.
j/ Excluding Surinam, Colombia, British Guiana, Dominican Republic, Ecuador and Haiti.
k/ Excluding Colombia.

/Table 31

Table 31

LATIN AMERICA: ANNUAL CUMULATIVE GROWTH RATES OF INSTALLED CAPACITY IN THE PUBLIC SERVICE

(Percentage)

Country	1938/59	1949/59	1955/59
First group			
Venezuela	...	19.9	20.5
Chile	6.3	5.3	2.7
Argentina	3.4	5.8	10.0
Cuba	7.4	11.9	13.9
Uruguay	5.8	4.2	3.9
Second group			
Surinam	...	...	8.3
Costa Rica	9.5	11.7 a/	18.3
Mexico	7.4	9.8	9.4
West Indies b/	...	12.0	7.0
Peru	6.1 c/	10.6 d/	13.0 e/
Colombia	...	...	8.9 f/
Brazil	6.2 c/	8.5	5.9
Panama g/	8.0	9.1	7.1
Third group			
British Guiana	...	...	5.3
Nicaragua	...	21.7 a/	25.0
Dominican Republic			
Bolivia	7.0	6.8	9.5
El Salvador	...	15.3	6.3
Ecuador	...	...	17.3
Guatemala	...	8.3	17.0
Honduras	...	15.5 a/	21.0
Paraguay	8.9	9.2	7.5
Haiti	...	...	...
Latin America	5.4 h/	8.4 i/	9.8 j/

Source: ECLA, on the basis of direct information and various publications.

a/ 1950/59.

b/ Trinidad, Tobago and Jamaica.

c/ 1940/59.

d/ 1952/59.

e/ 1954/59.

f/ 1956/59.

g/ Excluding the Canal Zone.

h/ Including 11 countries: Argentina, Bolivia, Brazil, Chile, Paraguay, Peru, Uruguay, Costa Rica, Cuba, Mexico and Panama.

i/ Excluding Surinam, British Guiana, Dominican Republic, Haiti, Ecuador, Colombia and the West Indies (Trinidad, Tobago and Jamaica).

j/ Excluding the West Indies, British Guiana, Dominican Republic, Haiti and Colombia.

/to improve

to improve their positions and relax somewhat the restrictions on the supply of power within certain systems.

The countries in the group with a high per capita consumption of electricity (see chapter III) were headed by Venezuela with an annual growth rate of 20 per cent maintained over in the last decade, followed by Cuba, with somewhat lower rates in the region of 12 per cent. The growth rate in Argentina was rather low, although there was a favourable turn during the period 1955-59. Uruguay maintained a fairly stable uniform growth rate, whereas in Chile there was a falling off during the period 1955-59.

In the second group attention is drawn to the cases of Costa Rica and Mexico, where, at their respective levels of consumption, the annual average increase in installed capacity for the last ten years has exceeded the increase in consumption. Peru and Colombia are among the countries with a high rate of expansion of installed capacity. The growth rates were lower in Brazil, where there was a marked decrease for the period 1955-59. Among the third group, Nicaragua and Honduras have had high growth rates of installed capacity in recent years.

It will be easier to interpret the various statistical tables if the following points are borne in mind:

(a) The sizable increase in installed capacity recorded for some countries is more apparent than real, because it includes the capacity of some obsolete units (mainly thermal) which although they still exist are more or less out of operation;

(b) In many cases the interconnexion of generating plants made it possible to increase utilization and reduce the required margin of reserve for existing installed capacity (mainly in Chile and Brazil);

(c) In 1959 a capacity of some 7.5 million kW was under construction, in a very large number of plants at all stages of completion that were expected to begin operating in the public utilities before 1965. An additional 28 million kW were represented by projects under study and by the capacity of plants under construction that were expected to begin operating in 1965 or later (see table 32). Basic data on installed capacity in the public service by year and by country can be found in annex D.

/Table 32

Table 32

LATIN AMERICA: INSTALLED CAPACITY OF PLANTS UNDER CONSTRUCTION AND UNDER STUDY, 1959

(Thousands of kW)

Country	Under construction a/	Under study
Argentina	980	4 000
Bolivia	25	100
Brazil	4 100	10 400
Colombia	135	1 700
Chile	305	1 100
Ecuador	25	90
Paraguay	...	350
Peru	540	1 500
Uruguay	110	950
Venezuela	680	3 000
Costa Rica	...	750
Cuba	30	...
El Salvador	...	90
Guatemala	...	60
Honduras	...	200
Mexico	530	3 900
Nicaragua	...	70
Panama	...	260
Total	7 460	28 520

Source: ECLA, based on direct information and various publications.

a/ Installed capacity to begin operating before 1965.

2. Sources of electric power

Of the 12.3 million kW of installed capacity in the public services in Latin America in 1959, 50.7 per cent represented hydroelectric plants and 49.3 per cent thermal plants (see table 33). Of the latter, between 70 and 75 per cent represented steam plants and the remainder internal combustion plants. As previously noted, although the proportion of hydroelectric capacity in total installed capacity remained the same from 1955 to 1959, there was a relative increase in the hydroelectric power generated, which in 1959 represented 60.9 per cent of the total public utility power. This was due to the higher plant factors that such plants acquire, for economic reasons, in systems where both types of generation are used.

On the basis of the analysis of production, the countries with the largest hydroelectric installed capacity in the public sector in 1959 were Brazil, Mexico, Chile and Colombia, with 3.1, 1.1, 0.5 and 0.5 million kW respectively. The countries where the proportion of hydroelectric capacity in the public utilities was highest were Bolivia, El Salvador, Brazil and Chile, where the proportion was over 80 per cent. Table 33 and statistical annex G show in addition the development of hydraulic and thermal capacity during the last twenty years by country, although they do not add anything to the information obtained on the basis of generation.

The data relating to installed capacity at internal combustion plants are usually very unreliable. Of the countries for which some information is available, Argentina and Mexico have the largest volume of installed capacity in the public sector (0.44 and 0.3 million kW respectively in 1958). The countries where internal combustion plants constitute the major proportion of public service capacity include Honuras, Ecuador, Nicaragua and Guatemala, where the respective percentages are 80, 40, 32 and 20.

A study of the development of generation (chapter III) shows that the share of diesel and petrol engines in the public utilities is decreasing in Latin American countries as in other regions of the world, whereas the equipment plans for a number of systems seem to indicate that gas turbines are likely to play a more prominent part in the near future in petroleum operations and within the public services, in the latter mainly in the way of supplying power at peak hours.

/Table 33

Table 33

LATIN AMERICA: PROPORTION OF INSTALLED CAPACITY IN THE PUBLIC SERVICE REPRESENTED BY HYDROELECTRIC CAPACITY a/

(Percentage)

Country	1938	1949	1955	1959
First group				
Venezuela	...	25.0	8.9	18.6
Chile	75.8	66.6	76.2	80.9
Argentina	2.6	2.98	6.0	12.2
Cuba	2.5	1.7	0.93	0.36
Uruguay	-	57.9	44.9	38.6
Second group				
Surinam	-	-	-	-
Costa Rica	100.0	100.0 b/	80.4	74.0
Mexico	65.6	48.3	58.4	53.5
West Indies c/	...	25.0 d/	13.5	10.3
Peru	72.1 e/	72.2 f/	65.5 g/	73.1
Colombia	...	...	...	72.1
Brazil	81.7 e/	83.6	80.0	81.9
Panama h/	-	-	-	10.0
Third group				
British Guiana	-	-	-	-
Nicaragua	...	12.5 b/	6.3	0.2
Dominican Republic	-	-	-	-
Bolivia	89.4	92.7	94.5	88.6
El Salvador	...	50.0	80.4	86.2
Ecuador	...	...	43.5	35.6
Guatemala	...	66.7 b/	71.9	46.7
Honduras	...	25.0 b/	14.3	18.8
Paraguay	-	-	-	-
Haiti	-	-	-	-
Latin America	46.0 i/	48.3 j/	50.9 k/	50.7

Source: ECLA, on the basis of direct information and various publications.
Note: The figures in brackets are estimates by ECLA.

a/ Further information is given in statistical annex G.
b/ 1950.
c/ Trinidad, Tobago and Jamaica.
d/ 1948.
e/ 1940.
f/ 1952.
g/ 1954.
h/ Excluding the Canal Zone.
i/ Excluding Venezuela, West Indies, Colombia, Nicaragua, El Salvador, Ecuador, Guatemala and Honduras.
j/ Excluding Colombia and Ecuador.
k/ Excluding Colombia.

/In December

In December 1959 over 70 per cent of the capacity of plants under construction in Latin America was hydroelectric. This proportion is of course somewhat higher than that of the capacity that will actually begin operating during a given period, because of the methods of construction and the longer period of completion required for hydroelectric plants. Whereas hydroelectric projects are carefully studied, and it is known what the final capacity of the project will be (even though the various units are installed at different stages), projects for thermal plants, which are flexible enough to allow of successive expansions, often provide only for the capacity of the initial installation. In addition, because hydroelectric plants take longer to construct, a longer period of years has to be allowed for before they can begin operating. In view of these considerations it is believed that during the sixties between 55 and 60 per cent of capacity installed will be hydroelectric.

3. Size of plants

In Latin America, as in other regions, there has always been a marked trend towards the construction of plants with a higher potential and the use of higher-capacity units, in order to reduce installation and operating costs. It often happens that large plants are installed that, in addition to supplying new systems, incorporate other formerly independent systems served by low-capacity plants that are uneconomic and not efficient enough to provide a good service. Table 34 shows this development for the public utilities in some countries for which information is available. In all cases the trend indicated is confirmed.

Table 35 shows the percentage distribution of installed capacity by size of plant (hydraulic and thermal), including both those already in operation and those that are at an advanced stage of completion. Attention is drawn to the high percentage of plants of between 50 and 200 MW and of over 200 MW, in such countries as Argentina, Brazil, Chile, Mexico, Colombia, Costa Rica, Venezuela, etc., especially among the hydraulic plants that are in the project stage.

/Table 34

Table 34

LATIN AMERICA: DEVELOPMENT OF PUBLIC SERVICE INSTALLED CAPACITY, BY PLANT. NUMBER OF PLANTS, AVERAGE CAPACITY AND PERCENTAGE OF INSTALLED CAPACITY

Country	Year	Capacity category											
		Under 500 kW			Between 501 and 5 000 kW			Between 5 001 and 20 000 kW			Over 20 000 kW		
		N°	kW	%	N°	kW	%	N°	kW	%	N°	kW	%
First group													
Chile	1938	49	178	4.8	28	1 350	21.0	3	9 240	15.4	4	26 500	58.8
	1955[a]	48	181	1.6	21	1 770	6.9	5	13 000	12.1	8	53 500	79.4
	1958	26	189	0.9	23	1 890	8.2	4	13 200	10.0	8	53 500	80.9
Argentina	1955[a]	626	131	5.3	122	1 467	11.7	21	10 033	13.8	9	117 844	69.2
	1958[b]	656	134	4.1	135	1 481	9.4	22	9 727	10.1	14	116 214	76.4
Second group													
Costa Rica	1955[c]	40	125	7.3	14	1 686	34.7	4	9 875	58.0	-	-	-
	1958	26	188	5.0	14	1 679	24.0	4	9 850	40.3	1	30 000	30.7
Mexico	1955[d]	413	71	2.3	88	1 589	11.1	25	10 378	20.6	17	48 884	66.0
	1958	190	161	1.5	100	1 705	8.3	44	9 698	20.8	26	54 855	69.4
Peru	1938[e]	122	86	10.0	10	1 130	10.8	2	13 700	26.3	1	55 230	52.9
	1955[g]	111	83	5.8	16	1 376	13.9	5	9 630	30.5	2	39 375	49.8
	1958[c]	291	53	7.6	19	1 782	16.4	5	11 370	27.6	2	49 875	48.4
Brazil	1955[g]	1 784	100	13.6	98	2 261	17.0	...	...	...	...	...	...
	1958[h]							26	14 327	13.8[i]	21	110 376	86.2
Third group													
Nicaragua	1955[c]	23	110	15.7	4	863	21.0	1	10 250	63.3	-	-	-
	1958	17	154	5.7	4	803	7.0	1	10 250	22.2	1	30 000	65.1
Bolivia	1955[c]	3	300	1.4	13	2 169	45.8	4	8 125	52.8	-	-	-
	1958	12	142	2.3	12	2 625	43.2	5	7 960	54.5	-	-	-
El Salvador	1955[c]	26	132	5.3	10	1 685	25.8	-	-	-	1	45 000	68.9
	1956	20	182	5.6	7	1 959	21.0	2	1 450	4.4	1	45 000	69.0
Ecuador	1955	621	31	29.4	20	890	27.1	3	9 500	43.5	-	-	-
	1958	379	43	9.4	16	119	22.6	4	12 300	58.0	-	-	-
Guatemala	1955[c]	46	105	3.4	5	1 528	21.3	4	5 850	65.3	-	-	-
	1958	36	136	1.1	10	2 097	47.4	3	6 133	41.5	-	-	-
Paraguay	1938	5	71	8.3	1	3 900	91.7	-	-	-	-	-	-
	1949[j]	6	97	6.1	-	-	-	1	8 900	93.9	-	-	-
	1955[a]	7	96	3.7	-	-	-	1	17 700	96.3			
	1958	8	133	3.7	-	-	-	-	-	-	1	27 700	96.3

Note: It is assumed that the figures for the years 1955 and 1958 include not less than 70 per cent and 85 per cent respectively of public service installed capacity.

a/ 1954.
b/ 1957.
c/ 1956
d/ 1953
e/ 1940
f/ 1952
g/ 1953
h/ 1957.
i/ Including only plants of over 10 000 kW.
j/ 1948.

/Table 35

Table 35

LATIN AMERICA: DISTRIBUTION OF PUBLIC SERVICE CAPACITY BY SIZE OF PLANT

(Percentage)

Country			Total (MW)	Size of plant: Under 5.0 MW	5.1 to 20 MW	20.1 to 50.0 MW	50.1 to 200 MW	Over 201 MW
First group								
1. Venezuela	Installed (1959)	Thermal a/	675	9.9	11.6	19.8	58.7	0.0
		Hydro	35	100.0	0.0	0.0	0.0	0.0
	To be installed b/	Thermal	620	0.0	6.6	0.0	54.7	38.7
		Hydro	412	0.0	5.0	13.3	0.0	81.7
2. Chile	Installed (1958)	Thermal	123	30.2	8.4	17.0	44.4	0.0
		Hydro	410	4.6	10.3	21.0	64.1	0.0
	To be installed b/	Thermal	268	8.4	0.0	16.8	74.8	0.0
		Hydro	1 126	1.5	1.4	10.0	42.8	44.3
3. Argentina	Installed (1958)	Thermal	1 919	20.9	9.7	6.3	13.1	50.0
		Hydro c/	304	6.3	26.0	25.5	42.2	0.0
	To be installed b/	Thermal	960	0.9	3.8	15.6	17.2	62.5
		Hydro	2 844	1.4	9.3	5.8	37.8	45.7
4. Cuba	Installed	Thermal	932	34.0	16.4	15.8	33.8	-
		Hydro	...	...	...	...	...	...
	To be installed b/	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
5. Uruguay	Installed (1958)	Thermal	203	10.7	5.5	0.0	83.0	0.0
		Hydro	128	0.0	0.0	0.0	100.0	0.0
	To be installed b/	Thermal	125	0.0	0.0	0.0	100.0	0.0
		Hydro	880	0.0	0.0	0.0	20.5	79.5
Second group								
6. Surinam	Installed (1958)	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
	To be installed b/	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
7. Costa Rica	Installed (1958)	Thermal	25	14.1	85.9	0.0	0.0	0.0
		Hydro	73	35.0	24.0	41.0	0.0	0.0
	To be installed b/	Thermal	-	-	-	-	-	-
		Hydro	745	0.0	5.4	4.0	54.4	36.2
8. Mexico	Installed (1958)	Thermal	976	18.2	27.4	25.1	29.3	
		Hydro	1 107	7.8	13.5	24.2	54.5	
	To be Installed b/	Thermal	704	4.3	7.2	28.2	60.3	
		Hydro	1 295	0.2	11.3	0.0	50.0	38.5
9. West Indies	Installed	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
	To be installed b/	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
10. Peru	Installed (1958)	Thermal	78	53.8	46.2	0.0	0.0	0.0
		Hydro	213	7.5	7.5	0.0	85.0	0.0
	To be installed b/	Thermal	232	10.9	31.1	0.0	58.0	0.0
		Hydro	1 867	0.0	1.6	2.6	38.0	57.8
11. Colombia	Installed (1958)	Thermal	177	32.8	38.9	28.3	0.0	0.0
		Hydro	453	17.2	14.3	27.5	41.0	0.0
	To be installed b/	Thermal	190	8.5	22.0	69.5	0.0	0.0
		Hydro	1 341	1.2	8.5	14.8	53.4	22.1
12. Brazil	Installed (1958)	Thermal	522	11.5	34.9	15.3	38.3	0.0
		Hydro	2 502	1.0	13.6	12.0	29.0	44.4
	To be installed b/	Thermal	619	0.0	16.0	34.9	8.7	40.4
		Hydro	3 864	2.1	6.6	2.8	24.1	64.4

/Table 35 (Cont'd)

Table 35 (Cont'd)

Country			Total (MW)	Size of plant				
				Under 5.0 MW	5.1 to 20 MW	20.1 to 50.0 MW	50.1 to 200 MW	Over 201 MW
13. Panama	Installed (1958)	Thermal	55	9.6	40.0	50.4	0.0	0.0
		Hydro	4.8	100.0	0.0	0.0	0.0	0.0
	To be installed[b]	Thermal	13	0.0	100.0	0.0	0.0	0.0
		Hydro	255	0.0	13.0	28.2	58.8	0.0
Third group								
14. British Guiana	Installed	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
	To be installed[b]	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
15. Nicaragua	Installed (1958)	Thermal	45	10.5	22.8	66.7	0.0	0.0
		Hydro	1	100.0	0.0	0.0	0.0	0.0
	To be installed[b]	Thermal	-	-	-	-	-	-
		Hydro	50	0.0	0.0	100.0	0.0	0.0
16. Dominican Republic	Installed (1958)	Thermal	87	...	...	...	...	...
		Hydro	-	-	-	-	-	-
	To be installed[b]	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...
17. Bolivia	Installed (1958)	Thermal	6	100.0	0.0	0.0	0.0	0.0
		Hydro	70	53.5	46.5	0.0	0.0	0.0
	To be installed[b]	Thermal	...	...	...	...	...	...
		Hydro	55	2.3	52.4	45.3	0.0	0.0
18. El Salvador	Installed (1958)	Thermal	9	100.0	0.0	0.0	0.0	0.0
		Hydro	56	19.6	0.0	80.4	0.0	0.0
	To be installed[b]	Thermal	15	0.0	100.0	0.0	0.0	0.0
		Hydro	85	0.0	17.7	82.3	0.0	0.0
19. Ecuador	Installed (1958)	Thermal	54	25.9	74.1	0.0	0.0	0.0
		Hydro	31	69.7	30.3	0.0	0.0	0.0
	To be installed[b]	Thermal	-	-	-	-	-	-
		Hydro	139	32.6	38.8	28.6	0.0	0.0
20. Guatemala	Installed (1958)	Thermal	19	63.1	36.9	0.0	0.0	0.0
		Hydro	26	56.2	43.8	0.0	0.0	0.0
	To be installed[b]	Thermal	13	0.0	100.0	0.0	0.0	0.0
		Hydro	72	0.0	30.6	69.4	0.0	0.0
21. Honduras	Installed (1958)	Thermal	7	100.0	0.0	0.0	0.0	0.0
		Hydro	4	100.0	0.0	0.0	0.0	0.0
	To be installed[b]	Thermal	2.5	100.0	0.0	0.0	0.0	0.0
		Hydro	111	0.0	0.0	50.5	49.5	0.0
22. Paraguay	Installed (1958)	Thermal	29	18.3	0.0	81.7	0.0	0.0
		Hydro	-	-	-	-	-	-
	To be installed[b]	Thermal	-	-	-	-	-	-
		Hydro	300	0.0	0.0	0.0	0.0	100.0
23. Haiti	Installed (1958)	Thermal	12	...	...	...	...	...
		Hydro	-	-	-	-	-	-
	To be installed[b]	Thermal	...	...	...	...	...	...
		Hydro	...	...	...	...	...	...

a/ The thermal capacity installed in 1958 was 621 MW (Venezuela).

b/ Represents plants under construction or at an advanced project stage.

c/ In 1958 hydraulic installed capacity amounted to 260 MW (Argentina).

4. Plant utilization

Average plant utilization is low in Latin America compared with the United States, but high compared with Europe. (European utilization in Europe excluding the Soviet Union in 1958 was 2,850 hours; in the United States it was 4,950 and in the Soviet Union 4,130).

In 1959 the total for all plants was 3,890 hours, the figures for the public and private sectors being 4,040 hours and 3,300 hours respectively (see table 36). In 1949 average utilization was 3,570 hours. The increase over the ten-year period is attributable mainly to interconnexion, with the resulting reduction of reserve capacity in percentage terms, to the diversification of consumption, to restrictions imposed at peak-lead hours, and to the increase of industrial consumption (in the last five years of the period), all of which raise the load factor.

With respect to utilization by the two types of plant, in 1959 the hydroelectric public service plants worked an average of 4,790 hours, and the thermal plants 3,250 hours.

The highest utilization factors in the public sector were in Brazil, Colombia, Cuba and Chile, where the average values were between 5,200 and 3,800 hours.

It can also be seen that, as might be expected, in countries with systems supplied by both hydroelectric and thermal plants the degree of utilization is higher in the former; it is often double or triple that for thermal plants.

Utilization in hydraulic plants in Argentina is low,[2/] even considerably lower than in thermal plants for the recent years studied, with values of between 2,400 and 3,600 hours.[3/]

2/ In Honduras and Nicaragua, where there is a similar situation, the hydraulic plants are very small and operate independently.

3/ Some supplementary engineering works were lacking in certain plants in the provinces of Mendoza and Cordoba, for example at Nihuil I (which in 1957 had a utilization of only 600 hours). Los Molinos I has an average utilization of 2,600 hours, which will be improved by the construction of the Anizacate dam. San Roque utilization is 3,100 hours because the regulating dam is awaiting completion, etc. Furthermore, some storage plants have been planned to work normally at peak hours.

/Table 36

Table 36

LATIN AMERICA: AVERAGE UTILIZATION IN PUBLIC SERVICE PLANTS

(Hours per year)

Country	Thermal			Hydraulic			Total		
	1949	1955	1959	1949	1955	1959	1949	1955	1959
First group									
Venezuela	3 057	2 967	3 754	3 829	5 028	629	3 250	3 151	3 174
Chile	1 109	2 070	895	3 759	3 873	4 477	2 874	3 444	3 792
Argentina	3 132	3 670	3 418	3 975	3 258	2 207	3 157	3 645	3 270
Cuba	4 259	4 081	3 805	4 333	4 667	3 500	4 260	4 086	3 804
Uruguay	946	2 191	2 345a/	3 789	5 297	5 938a/	2 593	3 586	3 734a/
Second group									
Surinam	...	2 250	1 846	-	-	-	...	2 250	1 846
Costa Rica	-	3 300	1 000	4 270	5 659	4 514	4 270	5 196	3 600
Mexico	3 488	3 799	2 223	5 020	3 792	5 037	4 227	3 795	3 729
West Indies	2 630	2 108	3 080	2 778	6 154	6 615	2 667	2 656	3 444
Peru	750	1 250	2 221	3 754	4 307	3 333	2 318	3 253	3 034
Colombia	...	...	3 232	...	....	4 642	...	...	4 249
Brazil	...	4 601	(4 059)	...	4 106	(5 498)	...	4 205	5 238
Panama	3 571	3 000	4 156	-	-	2 800	3 571	3 000	4 060
Third group									
British Guiana	...	2 385	3 063	-	-	-	...	2 385	3 063
Nicaragua	3 143	3 067	1 978	2 000	2 000	3 000	3 000	3 000	2 000
Dominican Republic	...	1 917	(2 920)	-	-	-	...	1 917	2 920
Bolivia	1 333	1 333	1 222	4 237	4 077	3 852	4 024	3 927	3 557
El Salvador	2 444	300	111	3 667	3 122	4 054	3 056	2 569	3 508
Ecuador	...	4 154	2 339	...	5 300	4 355	...	1 652	3 057
Guatemala	2 222	3 667	2 969	3 944	4 348	3 786	3 370	4 156	3 350
Honduras	3 000	3 167	2 308	4 000	5 000	4 000	3 250	3 429	2 625
Paraguay	2 700	2 833	3 000	-	-	-	2 700	2 833	3 000
Haiti	...	1 917	3 769	-	-	-	...	1 917	3 769
Total Latin America	3 034	3 562	3 245	4 278	4 068	4 785	3 423	3 819	4 042

a/ This figure is for 1958, since production in 1959 was greatly affected by the floods.

/In this

In this connexion it should be borne in mind that to the factors that determine the utilization of thermal plants another factor must be added in the case of hydraulic plants, namely, the hydrologic characteristics of the river used. In run-of-river plants whose installed capacity corresponds to a flow of low duration, and in storage plants planned mainly for a high level of exploitation of the water resource, the annual production of energy varies with the abundance or scarcity of precipitation.

With few exceptions, the main electricity systems of the region are based on hydroelectric plants whose installed capacity generally reflects high levels of hydrologic probability for the rivers concerned. It is also common in smaller systems for the base load to be supplied by run-of-river plants, while diesel units are available for peak hours and emergencies.

For a given system, reserve capacity is defined as the available installed capacity in excess of maximum demand. For the Latin American countries as a whole this concept is not generally valid, but the average reserve capacity in 1959 may be estimated as in the region of 10 per cent. However, there is still rationing in a number of systems and, as pointed out above, some of this reserve capacity is fictitious in that the nominal available capacity includes obsolete units that in practice are out of operation. Consequently the difference between the region's installed capacity and demand is dangerously narrow.

Chapter V

CONSUMPTION OF ELECTRICITY BY SECTORS

1. Distribution losses and net consumption

The difference between "generation" and "consumption" shown by the statistics, includes, in addition to the losses involved in any type of transmission of electricity and in consumption by the generating stations themselves during the process of generation, an undetermined amount of power which is used as a consumer good or a production factor, for not all the electricity supplied through the networks is properly measured.

In some small towns, tariff rates are set in such a way that subscribers pay a fixed amount each month, restrictions being placed on maximum demand but no provision being made for measuring the amount of power consumed; fraudulent consumption is not unusual, through the use of hidden connexions of interference with electricity metres. In properly established electricity systems, fraudulent consumption of this kind usually represents only small percentages of the total power generated, although it may be considerable in out-of-date distribution systems.

As a very general average of the different systems throughout the world, consumption by generating stations themselves reaches approximately five per cent of total power generated, depending on the size of the generating station concerned, its type - hydro or thermal - and whether, in the case of the hydro stations, they are provided with pumped storage tanks.

Similarly, the inevitable losses in the combined transmission and distribution of electricity usually vary between six and fifteen per cent, the lower figure corresponding to systems with no or very short transmission lines and distribution networks in very good condition. The higher figures correspond to systems fed by long-distance transmission lines and distribution networks in a poor state of repair. The average percentage for the latter was 10.0 for Europe and 8.2 for the United States.[1/]

1/ The percentage losses for the following countries, in 1958, were: Belgium 6.0, Czechoslovakia 8.8, Denmark 13.0, France 10.0, Greece 15.1, Hungary 10.7, Italy 15.9, Netherlands 7.5, Norway 13.0, Spain 19.2, Switzerland 8.7, United Kingdom 9.3, etc.

/Of the

Of the 49,700 million kWh generated by the public utilities in Latin America in 1959, only 41,100 million were registered as forming part of the area's economic activities. The balance (17.0 per cent) represented losses, unregistered consumption and consumption by central generating plants. Since about 40 per cent of the power output of public utilities is thermo-electric, exclusive of losses in transmission, and pumped storage tanks are but few in number (only in Brazil has power used in this way any significance, as it accounts for somewhat more than four per cent of power generated), this aspect of the situation in Latin America is not very satisfactory. Moreover, it has been gradually deteriorating over the past few years, the difference in 1949 amounting to only 15.2 per cent of the power generated. (See table 37).

Losses and unregistered consumption are very high (over 22 per cent in 1959) in some countries, including Honduras, Nicaragua, Paraguay and Panama. There is less justification for this in those countries because generation is entirely thermo-electric power in Paraguay and to a considerable extent in the other countries mentioned.

Considering that the main transmission and distribution losses vary in ratio to the square of the amperage, the power lost to consumption in peak load hours may very well exceed 20 per cent for Latin America as a whole, thus widening the gap between consumer demand and the power in fact supplied.2/

The chief reason for this is the overloading of the networks and the frequently defective construction of network expansions and extensions. This, in turn, is caused by:

(a) Lack of overall planning for the technical and economically adequate development of each network;

(b) Scarcity of financial resources;

2/ In many systems the problem of losses at peak load hours is even more serious, because with a view to checking overloading in the generating stations, the voltage and frequency are lowered, thereby further increasing the amperage and as a result bringing about further losses. To the cumulative effects of this process should be added the fact that consumers use voltage regulators to overcome voltage cuts and in so doing contravene regulations.

/Table 37

Table 37

LATIN AMERICA: LOSSES AND UNREGISTERED CONSUMPTION IN PUBLIC ELECTRICITY SERVICES

(Percentages)

Country b/	1938	1949	1955	1959
First group				
Venezuela	14.2	16.7	15.3	(14.2)
Chile	21.8 c/	13.1	16.4	17.8
Argentina	17.6	16.4	16.5	(18.8)
Uruguay	20.1	21.1	24.1	17.6 d/
Cuba	15.1	6.0	9.7	10.2
Second group				
Costa Rica	...	27.8 e/	21.1	15.0
Brazil	...	...	11.7	17.9
Mexico	14.5	13.9	18.0	(13.6)
Colombia	10.9	15.2	20.3	(23.8)
Panama	...	21.3	18.4	22.2
Peru	15.9 e/	16.1 f/	16.1 g/	(16.1)
Third group				
Bolivia	14.1	13.3	16.2	(15.2)
Nicaragua	...	20.8 e/	14.6	22.3
El Salvador	...	21.2 e/	19.1	18.0
Ecuador	...	(24.6) h/	27.6	(15.4)
Guatemala	...	19.8 e/	18.8	16.9
Paraguay	(27.3)	29.6	23.5	22.2
Honduras	...	23.1 e/	25.0	23.8
Latin America	16.5	15.2	15.2	17.4

Source: Direct information and various publications prepared by ECLA.

Note: The figures in brackets are ECLA estimates.

a/ Further information is given in statistical annex "K" at the end of this chapter.

b/ No information available for the countries not shown

c/ 1940.

d/ See note a/ in table 15.

e/ 1950.

f/ 1952.

g/ 1954.

h/ 1951.

/(c) Lack

(c) Lack of technical standards or failure to meet them in the design and construction of distribution networks;

(d) Shortage of technical staff at various levels.

2. General observations on consumption by sectors

Analysis of electricity consumption in the various sectors of the economy not only gives a better understanding of the differences in total consumption per unit of gross product in each country as a result of different economic structures, but also affords a suitable basis on which to project future power requirements in line with overall economic development plans and assumptions.

The detailed examination which this question warrants is unfortunately precluded by the absence of basic statistics or by a lack of uniformity in such statistics as are available. There is, in fact, a difference in the way the countries concerned classify consumption (household, commercial, public lighting, transport, industrial, etc.).

For Latin America as a whole, the percentage distribution of the 50,100 million kWh consumed in 1959[3/] was approximately as follows: industry and mining, 55 per cent; household, 25 per cent; commercial, 7 per cent; public lighting, 2 per cent; transport and other, 11 per cent. This pattern of distribution has only varied slightly over the past ten years.

(a) Relationship between electric power consumption as an end use and the gross national product other than in agriculture and mining

The combined total of household, commercial, public lighting and passenger transport consumption (approximately fifty per cent of the public services) constitutes what might be called non-industrial urban consumption which, allowing for a tolerable margin of error, represents

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3/ In the case of self-suppliers it is assumed that available data relate chiefly to consumption. Haiti, the Dominican Republic, British Guiana, the West Indies and Surinam, as well as plants with a capacity of less than 100 KW in Brazil, have been omitted for lack of consumption data.

electric power consumption as an end use or, more specifically, consumption as related to available personal income. Granting this margin of error, which in practice can be as much as 10 per cent in arriving at the figure for electric power consumption strictly considered as an end use, the data available make it possible to analyse the relationship between urban per capita consumption and income, the latter being measured by gross national product other than in agriculture and mining.

Unlike the industrial and mining sector, the household-commercial sector, which is the main component of non-industrial urban consumption, is composed of a large number of consumers of the same type. This sector accordingly lends itself readily to the application of statistical analysis procedures the purpose of which is to reach findings applicable to underdeveloped countries, based on the experience of the more advanced countries. In studying consumption in the household-commercial sector, however, it should never be forgotten that there is a tendency for substitution for many purposes as between gas, paraffin, etc. and electricity.

The average 1956-58 figures for 32 countries, including 15 Latin American countries, serve as a basis for figure VII and the corresponding trend line which indicates an elasticity of 1.4 and a degree of correlation of about 0.80.

Of the Latin American countries appreciably below the trend line, Venezuela, Argentina and Peru - all oil-producing countries - probably have a high consumption of hydrocarbons in the household, commercial and transport sectors, and this would explain their position in the figure. It is nevertheless expected that these countries, together with Paraguay, Guatemala, and Nicaragua will increase their consumption of electricity when supply conditions improve and until they reach the level of the average trend in other countries in accordance with prevailing urban income levels.

(b) Relationship between industrial and mining consumption and the contribution of these sectors to gross product

The industrial and mining sectors are generally the heaviest consumers of electricity in the various countries. Of the 44 cases studied in Latin America and other regions, 33 (i.e. 75 per cent) showed an industrial and

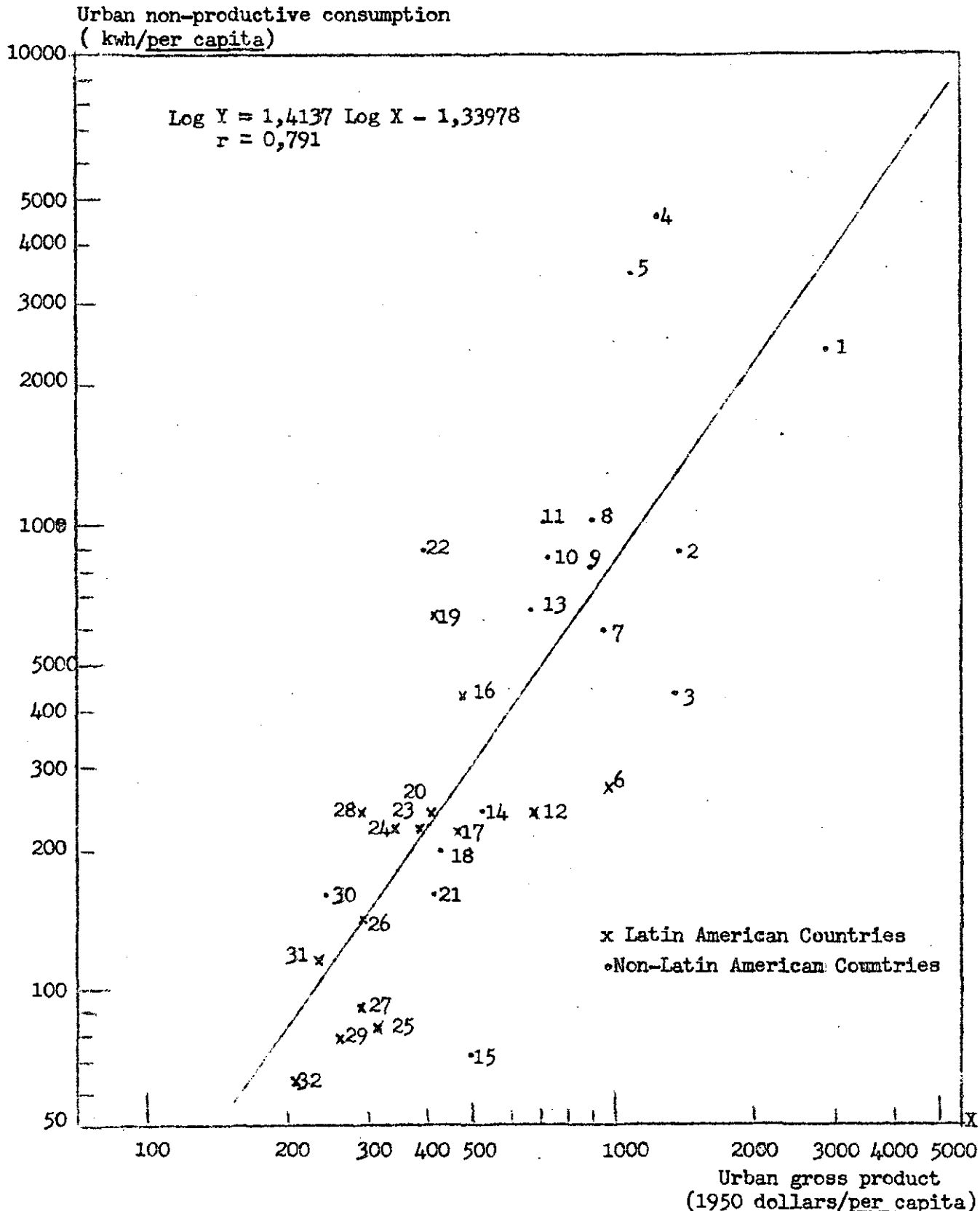
ORDER OF COUNTRIES
(Figure VII)

1. United States of America
2. Finland
3. Belgium and Luxembourg
4. Norway
5. Switzerland
6. Venezuela
7. Federal Republic of Germany
8. United Kingdom
9. Denmark
10. Ireland
11. Austria
12. Argentina
13. Netherlands
14. Philippines
15. Turkey
16. Brazil
17. Panama
18. Portugal
19. Costa Rica
20. Mexico
21. Ceylon
22. Japan
23. Chile
24. Colombia
25. Nicaragua
26. El Salvador
27. Guatemala
28. Uruguay
29. Peru
30. Greece
31. Ecuador
32. Paraguay

Figure VII

CORRELATION BETWEEN URBAN NON-PRODUCTIVE PER CAPITA CONSUMPTION OF ELECTRICITY AND THE URBAN GROSS PRODUCT PER CAPITA a/

Logarithmic scale



a/ Non-productive consumption is considered to be difference between the sum of mining and industrial consumption and total consumption.
The urban gross product is considered to be the difference between the sum of the gross products for agriculture and mining and the total gross domestic

mining consumption of over 50 per cent of the total, and 26 (or over 50 per cent of the countries) showed a figure of over 60 per cent.

Countries where industrial diversification is slight may show a wide disparity in the relationship between electric power consumption and the contribution of the industrial sector to gross product. This disparity would seem to reflect the differences in the electric power consumption required for unit production in each branch; for example, 20,000 kWh are required to refine one ton of aluminium, 2,600 kWh to refine a ton of electrolitic copper and 50 kWh to refine a ton of crude petroleum.

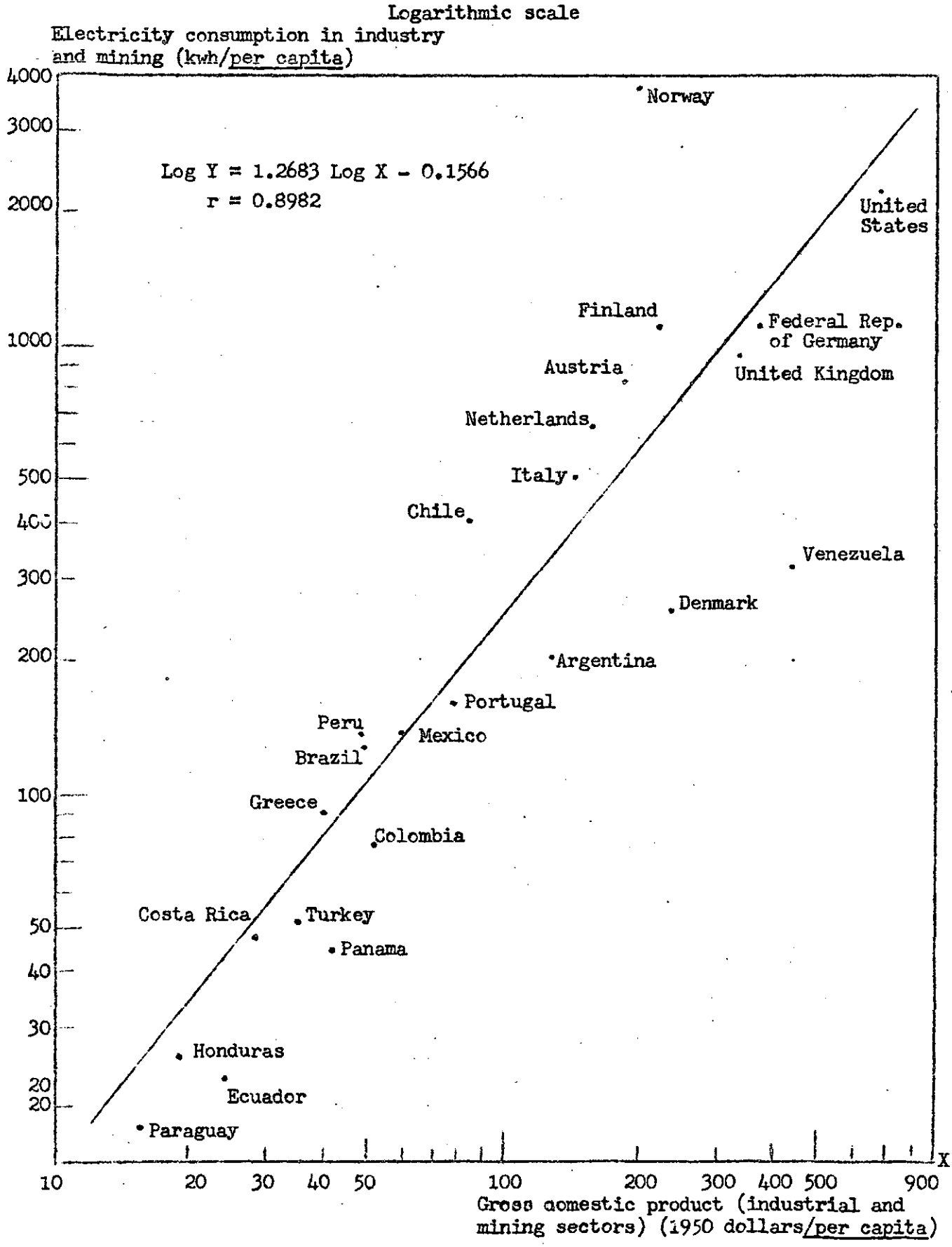
Despite the foregoing remarks, figure VIII, indicating the per capita relationship of electric power consumption in mining and industry to the share of the gross national product of those sectors, expressed in 1950 dollars, was prepared on the basis of average data for the 1956-58 period, covering 24 countries, 12 of them in Latin America. Elasticity was low (1.27) and the degree of correlation was 0.90. The central part of the figure, close to the regression line - between 500 and 100 kWh per capita - is occupied by Argentina, Brazil, Chile, Mexico and Peru, the most highly industrialized of the Latin American countries. This correlation and the one mentioned earlier relate to partial aspects of the broader process examined in figure III which is based on a larger number of countries and shows less scattering.

Of the Latin American countries, Chile, Peru and Brazil are well above the line. The first two have high electricity consumption in the mining industry and Brazil is remarkable for its industrial development. Venezuela is very much below the trend line, for its most dynamic activity - petroleum - is not, as has already been shown, a large consumer of electricity per unit of output. The situation with respect to Argentina, Colombia, Panama, Honduras, Ecuador and Paraguay shows that in some cases their industrial and mining activities required a proportionately smaller quantity of electric power and that in others there has been only a small degree of mechanization.

/Figure VIII

Figure VIII

CORRELATION BETWEEN ELECTRICITY CONSUMPTION AND THE GROSS DOMESTIC PRODUCT IN THE INDUSTRIAL AND MINING SECTORS : AVERAGE 1956-58



3. Non-industrial urban consumption

The total consumption of electric power supplied by public electricity services in Latin America in 1959 was, as indicated earlier, 41,100 million kWh. Of this amount non-industrial urban consumption amounted to 24,500 million kWh, or 60 per cent.

With the urban population estimated at 85 million, average per capita consumption for the whole of 1959 was 289 kWh. Distribution of this consumption was rather irregular, as may be seen from table 38 which shows a decreasing rate of consumption within the groups established above. Only Cuba and Venezuela are above the regional average in the first group and Costa Rice and Brazil in the second group. Costa Rica is far above the other countries in this respect as a result, inter alia, of its vast hydroelectric potential - in contrast with the shortage of other energy resources - and the vigorous electrification policy which it has instituted, particularly since 1949.

The percentage of this consumption represented by power supplied by public utilities showed a marked tendency to rise in a few countries, particularly in the 1949-55 period. These countries are Cuba, Argentina and Uruguay in the first group, Costa Rica, Brazil and Mexico in the second group, and Bolivia, El Salvador and Paraguay in the third group. (See table 39).

Table 40 gives an idea of this type of consumption by countries and its evolution over the years. The highest rate of growth over the last decade has occurred in Venezuela, Nicaragua and Honduras with annual rates of increase of between 18 and 22 per cent for the period 1955-59 (see table 47). It should be remembered that at the present stage of development of the Latin American countries, there are two factors which have an appreciable effect on this kind of consumption. These are:

(i) increases in the number of consumers as a result of population increases in towns and the extension of publicly owned electricity systems, and

(ii) increases in specific per capita consumption as a result of higher average levels of income and its better distribution (higher standards of living and substitution for other sources of power).

/Table 38

Table 38

LATIN AMERICA: NON-INDUSTRIAL URBAN PER CAPITA CONSUMPTION OF PUBLIC SERVICE ELECTRICITY, 1959

Country a/	Non-industrial consumption (millions of kWh)	Urban population (thousands)	Consumption per urban inhabitant
First group			
Cuba	1 317	3 596	366
Venezuela	(1 401)	3 942	(355)
Argentina	(3 464)	14 224	(244)
Uruguay	556 b/	2 217	251 b/
Chile	1 066	4 768	224
Second group			
Costa Rica	283	407	695
Brazil	10 509 c/	22 871	459
Panama	127	456	279
Mexico	4 049 d/	5 350	(264)
Colombia	(1 517)	6 552	(232)
Peru	(413)	4 299	(96)
Third group			
El Salvador	122	786	155
Ecuador	(169)	1 450	(117)
Nicaragua	53	499	106
Guatemala	114	1 142	100
Bolivia	(126)	1 426	(88)
Paraguay	38	538	71
Honduras	25	371	67
Latin America	25 349	84 894	298

Source: Direct information and various publications prepared by ECLA.

Note: The figures in brackets are ECLA estimates.

a/ No information available for the countries not shown.

b/ See note a/ in table 15.

c/ Includes estimated consumption of 2 460 million kWh supplied by public service undertakings with outputs of under 100 kW.

d/ Includes estimated consumption of 279 million kWh of imported electricity intended for this type of consumption.

/Table 39

Table 39

LATIN AMERICA: PARTICIPATION OF NON-INDUSTRIAL URBAN CONSUMPTION IN THE PUBLIC SERVICES a/

(Percentages)

Country	1938	1949	1955	1959
First group				
Cuba	...	68.4	71.2	70.8
Venezuela	(62.5)	60.2	58.6	(60.0)
Argentina	56.8	52.7	53.9	56.5
Uruguay	...	(48.0)	51.3	54.6 c/
Chile	61.6 d/	58.0	55.1	54.3
Second group				
Costa Rica	...	51.2 e/	92.3	92.5
Brazil	...	50.8	64.8	59.0
Panama	...	81.4	81.7	80.4
Mexico	(45.8)	53.4	55.8	(55.8)
Colombia	76.7	75.5	72.9	(73.8)
Peru	51.5 d/	53.5 f/	52.0 g/	(51.7)
Third group				
El Salvador	...	67.3 e/	70.7	65.2
Ecuador	...	87.6 h/	82.6	(75.3)
Nicaragua	...	73.7 e/	58.6	72.6
Guatemala	...	67.1 e/	67.6	68.3
Bolivia	27.3	46.2	48.6	(52.8)
Paraguay	...	63.2	64.1	67.9
Honduras	...	80.0 e/	72.3	78.1
Latin America	53.8	53.1	60.8	59.5

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA estimates.

a/ Information for other years appears in statistical annex "H".
b/ No information available for the countries not shown.
c/ See note a/ of table 15.
d/ 1940.
e/ 1950.
f/ 1952.
g/ 1954.
h/ 1951.

/Table 40

Table 40

LATIN AMERICA: NON-INDUSTRIAL URBAN CONSUMPTION OF ELECTRICITY

(Millions of kWh)

Country a/	1938	1949	1955	1959
First group				
Argentina	1 089	1 869	2 656	(3 464)
Cuba	...	485	851	1 317
Chile	308 b/	554	890	1 066
Uruguay	...	(217)	398	556c/
Venezuela	(60)	228	634	(1 401)
Second group				
Brazil d/	...	2 663	7 722	10 509
Colombia	201	596	1 057	(1 517)
Costa Rica	...	104 e/	193	283
Mexico f/	839	1 676	2 703	4 049
Panama	...	48	76	127
Peru	136 b/	207 g/	247 h/	(413)
Third group				
Bolivia	15	66	88	(126)
Ecuador	...	(78) i/	128	(169)
El Salvador	...	35 e/	75	122
Guatemala	...	49 e/	73	114
Honduras	...	8 e/	13	25
Nicaragua	...	14 e/	24	53
Paraguay	...	12	25	38
Latin America	2 648	8 909	17 853	25 349

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA estimates.

a/ No information available for the countries not shown.
b/ 1940.
c/ See note a/ in table 15.
d/ Includes consumption estimated at 1 574 and 2 460 million kWh for 1955 and 1959 respectively of electricity supplied by public service enterprises with outputs of under 100 kW.
e/ 1950.
f/ Includes, for 1938, 1949, 1955 and 1959 consumption of 11, 72, 168 and 279 million kWh respectively of imported electricity intended for this type of consumption.
g/ 1952.
h/ 1954.
i/ 1951.

/(a) Domestic

(a) Domestic consumption

This sector accounted for 56 per cent of non-industrial urban consumption[4/] in Latin America in 1959, consuming a total of 12,600 million kWh as compared with a figure of only 4.5 million in 1949 (see table 41).

The growth rate during the past ten years has remained steady at an annual cumulative rate of about 11 per cent for the countries as a whole. In 1959 it amounted to an urban per capita average of about 150 kWh, or approximately twice the amount consumed in 1949.

The share of the total represented by public electricity services was 33.2 per cent in 1959 (in 1938 it was 27.5 per cent), ranging from the highest in Costa Rica (73.2 per cent) to the lowest in Mexico (15.6 per cent). With the exception of Chile, Colombia, Ecuador, Venezuela, Nicaragua and Panama which, within the framework of an absolute increase, show a slight decline in the share of consumption of the public electricity service (during the last two decades) and Brazil which shows relative stability, in all the other countries the public electricity service has made advances (see table 42). Household consumption is very considerable as compared with other forms of electricity consumption in the early stages of economic development, it declines as development proceeds, to rise subsequently to higher levels (as has occurred in the United States).

In certain major urban centres (Buenos Aires, Santiago, Bogota, Caracas, etc.), the availability of gas has been a factor of some importance in restricting the use of electricity in the household; in some smaller towns, paraffin has had the same effect. On the other hand, in other towns, such as San Jose and La Paz, where hydroelectric power is available and gas supply facilities are lacking, consumption of electric power for cooking and ironing, for example, is very high.

(b) Commercial consumption

Although the classification of commercial consumption is not uniform, it usually covers commercial activities, including small industry and

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4/ Excluding public service generating stations in Brazil with an output of less than 100 kW.

/Table 41

Table 41

LATIN AMERICA: HOUSE HOLD CONSUMPTION OF PUBLIC SERVICE ELECTRICITY a/

(Millions of kWh)

Country b/	1938	1949	1955	1959
First group				
Argentina c/	619	1 326	2 129	2 906
Cuba c/	...	343	725	1 141
Chile	124 d/	244	391	462
Uruguay	...	(127)	273	401 e/
Venezuela f/	(60)	228	634	1 401
Second group				
Brasil	...	1 033	1 756 g/	2 676 g/
Colombia	201	(328)	1 057 f/	1 517 f/
Costa Rica	...	83 h/	156	224
Mexico	(229)	387	691	1 054
Panama	...	18	28	47
Peru c/	106 d/	177 i/	216 j/	368
Third group				
Bolivia	9	45	66	90
Ecuador c/	...	56 k/	95	127
El Salvador	...	10 h/	33	55
Guatemala	...	28 h/	45	74
Honduras	...	6 h/	10	16
Nicaragua	...	10 h/	17	32
Paraguay c/	...	9	21	33
Latin America	1 348	4 458	8 543 g/	12 605 g/

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA estimates.

a/ Information for other years appears in statistical annex "L".
b/ No information available for the countries not shown.
c/ Includes commercial consumption.
d/ 1940.
e/ See note b/ in table 15.
f/ Includes the following types of consumption: commercial, public lighting, transport and other.
g/ Excluding for Brazil, public service household consumption provided by undertakings with outputs of under 100 kW, for lack of information.
h/ 1950.
i/ 1952.
j/ 1954.
k/ 1951.

/Table 42

Table 42

LATIN AMERICA: HOUSEHOLD ELECTRICITY CONSUMPTION IN RELATION TO THE TOTAL OF PUBLIC SERVICES a/

(Percentages)

Country	1938	1949	1955	1959
First group				
Argentina b/	32.3	37.4	43.2	47.4
Cuba b/	...	48.4	60.7	61.3
Chile	24.8 c/	25.5	24.2	23.5
Uruguay	...	28.1	35.2	39.4 d/
Venezuela e/	62.5	60.2	58.6	60.6
Second group				
Brazil	...	19.7	18.5	19.6
Colombia	76.7 e/	41.6	72.9 e/	73.8 e/
Costa Rica	...	72.8 f/	74.6	73.2
Mexico	12.7	12.9	15.2	15.6
Panama	...	30.5	30.1	29.7
Peru b/	40.1 c/	45.7 g/	45.5 h/	45.1
Third group				
Bolivia	16.4	31.5	36.5	37.7
Ecuador b/	...	62.9 i/	61.3	56.3
El Salvador	...	19.2 b/	31.1	29.4
Guatemala	...	38.2 b/	41.7	44.3
Honduras	...	60.0 b/	55.6 b/	50.0
Nicaragua	...	52.6 b/	41.5	43.8
Paraguay b/	...	47.4	53.9	58.9
Latin America	27.5	27.8	31.5	33.2

Source: Direct information and various publications prepared by ECLA.

a/ Information for other years appears in statistical annex "M".
b/ Includes commercial consumption.
c/ 1940.
d/ See note a/ in table 15.
e/ Includes commercial, public lighting and transport consumption.
f/ 1950.
g/ 1952.
h/ 1954.
i/ 1951.

/handicrafts. For

handicrafts. For rates purposes, this consumption begins when the contracts for the supply of electric power are signed.

Commercial consumption amounted to 3,400 million kWh in 1959 for Latin America as a whole, indicating an annual rate of growth of 9.4 per cent for the period 1955-59. Commercial consumption accounted for 9 per cent of the power supplied by the public electricity service, and a country-by-country breakdown shows a range of about 8 to 20 per cent.[5/] The general trend indicates a relative increase in this type of consumption, although in Chile, Uruguay, El Salvador and Guatemala, no change or a decrease is to be noted.

(c) Public lighting

In some systems this includes not only public lighting proper but also consumption by government offices. This means that, as in other cases, the data are not strictly homogeneous. In 1959 this consumption amounted to 810 million kWh for the region as a whole, with an annual growth rate of 9.7 per cent in the 1955-59 period. (See table 44). Its share of the power provided by public electricity services was 2.1 per cent, with a slight trend downwards. The same figure country-by-country would seem to vary between 2 and 7 per cent calculated only for the lighting of streets, parks and public squares. The figures for Colombia, Ecuador and Panama, which are above this average, probably include other items.

The share of public lighting would seem with rare exceptions (Ecuador, Mexico, Panama, Honduras and Nicaragua) to be subject to slight downward trends over time or to remain more or less stationary.

(d) Transport and other

Data relating to this sector also lack uniformity. The main item of consumption in this respect is, however, transport itself and more particularly urban passenger transport, although in some countries (Argentina, Brazil, Chile and Mexico) suburban transport has a fairly high incidence.

Consumption under this heading for Latin America as a whole amounted to 5,800 million kWh in 1959 (see table 45) with a cumulative annual rate

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5/ A different classification system is probably used in Panama, where the rate is over 30 per cent.

Table 43

LATIN AMERICA: COMMERCIAL CONSUMPTION OF PUBLIC SERVICE ELECTRICITY a/

Country b/	1959 (millions of kWh)	Percentage of public service 1949	1955	1959
First group				
Argentina	c/	c/	c/	c/
Cuba	c/	c/	c/	c/
Chile	172	8.5	8.5	8.8
Uruguay	95 d/	(9.3)	10.6	9.3 d/
Venezuela	c/	c/	c/	c/
Second group				
Brazil	1 978	19.7	18.5	19.6
Colombia	c/	(11.9)	c/	c/
Costa Rica	43	13.1 e/	13.9	14.1
Mexico	(966)	8.8	16.4	(14.3)
Panama	61	37.3	43.0	38.6
Peru	c/	c/	c/	c/
Third group				
Bolivia	(31)	11.9	10.5	(13.2)
Ecuador	c/	c/	c/	c/
El Salvador	31	15.4 e/	16.0	16.6
Guatemala	24	15.1 e/	15.7	14.3
Honduras	5	c/	c/	c/
Nicaragua	8	c/	4.9	11.0
Paraguay	c/	c/	c/	c/
Latin America	3 409	6.8	9.0	9.0

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA .
a/ Information for other years appears in statistical annexes "L" and "M".
b/ No information available for the countries not shown.
c/ Included in household consumption.
d/ See note a/ in table 15.
e/ 1950.

/Table 44

Table 44

LATIN AMERICA: PUBLIC LIGHTING CONSUMPTION a/

Country b/	1959 (millions of kWh)	Percentage of public service		
		1949	1955	1959
First group				
Argentina	166	3.7	3.0	2.7
Cuba	c/	c/	c/	c/
Chile	76	3.7	3.6	3.9
Uruguay	24 d/	3.3	2.7	2.4 d/
Venezuela	e/	e/	e/	e/
Second group				
Brazil	c/	c/	c/	c/
Colombia	e/	e/	e/	e/
Costa Rica	e/	c/	c/	c/
Mexico	426	7.5	5.6	6.3
Panama	19	10.2	8.6	12.0
Peru	45	7.8 f/	6.5 g/	5.6
Third group				
Bolivia	5	2.8	1.6	1.9
Ecuador	31	11.2 h/	16.1	13.9
El Salvador	6	c/	3.8	3.2
Guatemala	5	c/	c/	3.0
Honduras	2	c/	5.6	6.3
Nicaragua	4	c/	4.9	5.5
Paraguay	3	5.3	5.1	5.4
Latin America	811	3.8	2.1	2.1

Source: Direct information and various publications prepared by ECLA.

a/ Information for other years appears in statistical annexes "L" and "M".

b/ No information available for the countries not shown.

c/ Included in transport and other consumption.

d/ See note a/ in table 15.

e/ Included in household consumption.

f/ 1952.

g/ 1954.

h/ 1951.

/Table 45

Table 45

LATIN AMERICA: TRANSPORT AND OTHER CONSUMPTION OF PUBLIC SERVICE ELECTRICITY a/

Country b/	1959 (millions of kWh)	Percentage of public service		
		1949	1955	1959
First group				
Argentina	(392)	11.6	7.7	(6.4)
Cuba c/	176	20.0	10.5	9.5
Chile	356	20.3	18.8	18.1
Uruguay	36 d/	(7.3)	2.8	3.5 d/
Venezuela	e/	e/	e/	e/
Second group				
Brazil c/	3 395	20.8	32.7	24.9
Colombia	e/	(2.5)	e/	e/
Costa Rica c/	16	5.3 f/	3.8	5.2
Mexico	(1 324)	24.2	18.5	(19.6)
Panama	-	3.4	-	-
Peru	-	-	-	-
Third group				
Bolivia	-	-	-	-
Ecuador	(11)	13.5 g/	5.2	(5.1)
El Salvador	30	32.7 f/	19.8	16.0
Guatemala	11	13.7 f/	10.2 c/	6.7
Honduras	2	20.0 f/	11.1	6.2
Nicaragua	9	21.1 f/	7.3	12.3
Paraguay	2	10.5	5.1	3.6
Latin America	5 758	16.7	18.2	15.1

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA estimates.

a/ Information for other years appears in statistical annexes "L" and "M".
b/ No information available for the countries not shown.
c/ Includes public lighting.
d/ See note a/ in table 15.
e/ Including household consumption.
f/ 1950; includes public lighting.
g/ 1951.

/of growth

of growth of 4.4 per cent in the 1955-59 period. Its share of the total public electricity service provided in the area was 15.1 per cent in 1959, with a relatively stable consumption trend. In Argentina, Brazil and Chile, the share of transport in total power consumption has been declining (although in Brazil only since 1955), while in Mexico it has risen slightly after a decline in the 1949-55 period. The majority of the countries which already have a lower rate of per capita consumption for transport, are also subject to a gradual decline in the overall figure for this type of consumption. In absolute terms, Argentina, Chile and Brazil have shown a slight increase in electricity consumption for transport and it is expected that Chile will show an appreciable increase in 1962 with the electrification of the Santiago - Chillán railway line, which will later, in accordance with existing plans, be extended to Temuco.

4. Industrial and mining consumption

Industry and mining accounted for about 27,500 million kWh of the total electricity consumed in Latin America in 1959. The equivalent figure for 1949 was 10,100 million kWh and for 1955, 18,900 million.

Five countries - Brazil, Argentina, Mexico, Chile and Venezuela - together accounted for more than four fifths (81.2 per cent) of this total (see table 46).

Industrial and mining consumption (as a production factor) accounted for 54.9 per cent of total Latin American power consumption in 1959. In the countries with a high degree of manufacturing and export activities requiring large-scale electricity input - Peru, Chile, Bolivia, Honduras, Nicaragua, Venezuela - it accounts for about 65 per cent or more of total electricity consumption (see table 47).

The growth of consumption in the industrial and mining sector shows an upward trend: the annual cumulative rate increased from 6.4 per cent in the period 1938-59 to 7.3 per cent in 1949-59 and 9.8 per cent in 1955-59 (see table 48).

A comparison shows that this growth rate exceeded that of manufacturing output, which showed growth rates of only 5.6 per cent in 1949-59 and 5.9 per cent in 1955-59.

/Table 46

Table 46

LATIN AMERICA: INDUSTRIAL AND MINING CONSUMPTION OF ELECTRICITY a/

(Millions of kWh)

Country b/	1938	1949	1955	1959
First group				
Argentina	1 231	2 412	3 175	(4 761)
Cuba	...	557	713	1 071
Chile	1 543 c/	2 256	2 718	3 108
Uruguay	...	(235)	378	(439)
Venezuela	(161)	(707)	(1 559)	(2 524)
Second group				
Brazil	...	...	4 466	7 087
Colombia	101	393	823	(1 189)
Costa Rica	...	34 d/	47	46
Mexico	1 372	2 217	3 400	(4 890)
Panama	...	17	37	56
Peru	451 c/	769 e/	1 025 f/	(1 642)
Third group				
Bolivia	(165)	233	257	(251)
Ecuador	...	(34) g/	72	(118)
El Salvador	...	39 d/	45	72
Guatemala	...	47 d/	67	95
Honduras	...	39 d/	42	51
Nicaragua	...	70 d/	93	100
Paraguay	...	17	26	33
Latin America	5 024	10 076	18 943	27 534

Source: Direct information and various publications prepared by ECLA.
Note: The figures in brackets are ECLA estimates.

a/ Information for other years appears in statistical annex "L".
b/ No information available for the countries not shown.
c/ 1940.
d/ 1950.
e/ 1952.
f/ 1954.
g/ 1951.

/Table 47

Table 47

LATIN AMERICA: CONSUMPTION IN THE INDUSTRIAL AND MINING SECTOR AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION

(Percentages)

Country	1938	1949	1955	1959
First group				
Argentina	53.1	56.3	54.5	(57.9)
Cuba	...	53.5	45.6	44.8
Chile	83.4 a/	80.3	75.3	74.5
Uruguay	...	(52.0)	48.7	(45.4)
Venezuela	(78.9)	(75.6)	(71.1)	(64.3)
Second group				
Brazil b/	...	...	42.1	46.8
Colombia	33.4	39.7	43.8	43.9
Costa Rica	...	24.6 c/	19.6	14.0
Mexico	(62.4)	58.0	57.3	(56.5)
Panama d/	...	26.2	32.7	30.6
Peru	76.8 a/	78.8 e/	80.6 f/	(79.9)
Third group				
Bolivia	(86.8)	77.9	74.5	(66.6)
Ecuador	...	21.4 e/	36.0	(41.1)
El Salvador	...	52.7 c/	37.5	37.1
Guatemala	...	49.0 c/	47.9	45.5
Honduras	...	83.0c/	76.4	67.1
Nicaragua	...	83.3 c/	79.5	65.4
Paraguay	...	58.6	51.0	46.5
Latin America	65.5 g/	62.0 h/	54.0	54.9

Note: The figures in brackets are ECLA estimates.

a/ 1940.

b/ See note p/ in statistical annex "L".

c/ 1950.

d/ Does not include the Canal Zone for lack of information.

e/ 1951.

f/ 1954.

g/ Includes Argentina, Chile, Venezuela, Colombia, Mexico, Peru and Bolivia.

h/ Excluding Brazil.

/Table 48

Table 48

LATIN AMERICA: BREAKDOWN OF ELECTRICITY CONSUMPTION BY TYPES OF CONSUMER

(Percentage average annual growth rates)

Country a/	Period	Public service		Industry and mining
		Non-industrial urban	Industrial	
Argentina	1938-1959	(5.6)	(5.5)	(6.7)
	1949-1959	(6.4)	(4.8)	(7.0)
	1955-1959	(6.9)	(4.0)	(10.7)
Bolivia	1938-1959	(10.7)	(5.0)	(2.0)
	1949-1959	(6.7)	(3.8)	(0.7)
	1955-1959	(9.4)	(4.8)	(-0.6)
Brazil	1938-1959	...	...	...
	1949-1959	11.7	8.1	...
	1955-1959	7.0	13.8	12.3
Colombia	1938-1959	(10.1)	(11.9)	(12.5)
	1949-1959	(9.8)	(10.8)	(11.7)
	1955-1959	(9.5)	(8.2)	(9.6)
Chile	1938-1959 b/	6.8	8.4	3.8
	1949-1959	6.8	8.3	3.3
	1955-1959	4.6	5.5	3.4
Ecuador	1938-1959	...	...	...
	1949-1959 c/	(10.1)	(22.6)	(16.8)
	1955-1959	(7.2)	(20.0)	(13.1)
Paraguay	1938-1959	...	...	...
	1949-1959	12.4	9.9	6.9
	1955-1959	11.0	6.5	6.1
Peru	1938-1959 b/	(6.0)	(6.2)	(7.0)
	1949-1959 d/	(10.3)	(12.2)	(11.5)
	1955-1959 e/	(10.8)	(12.0)	(9.9)
Uruguay	1938-1959	...	...	...
	1949-1958	11.0	7.9	7.9
	1955-1958	11.8	7.0	7.0

Note: The figures in brackets are ECLA estimates.

a/ There is no information available for the countries not appearing in the table.

b/ 1940-59.

c/ 1951-59.

d/ 1952-59.

e/ 1954-59.

/Table 48 (Cont'd)

Table 48 (Cont'd)

Country a/	Period	Public service		Industry and mining
		Non-industrial urban	Industrial	
Venezuela	1938-1959	(16.2)	(16.8)	(14.0)
	1949-1959	(19.8)	(20.0)	(13.6)
	1955-1959	(21.9)	(20.2)	(12.8)
Costa Rica	1938-1959	...	...	...
	1949-1959 f/	11.8	9.7	3.4
	1955-1959	10.0	9.5	-0.5
Cuba	1938-1959	...	...	...
	1949-1959	10.5	9.3	6.8
	1955-1959	11.5	12.1	10.7
El Salvador	1938-1959	...	...	...
	1949-1959 f/	14.9	16.1	7.0
	1955-1959	12.9	20.3	12.5
Guatemala	1938-1959	...	...	...
	1949-1959 f/	9.8	9.2	8.1
	1955-1959	11.8	10.9	9.1
Honduras	1938-1959	...	...	...
	1949-1959 f/	13.5	14.9	3.0
	1955-1959	17.8	8.8	5.0
Mexico	1938-1959	(7.5)	(5.5)	(6.2)
	1949-1959	(8.9)	(7.9)	(8.2)
	1955-1959	(10.4)	(10.4)	(9.5)
Nicaragua	1938-1959	...	...	...
	1949-1959 f/	15.9	16.7	4.0
	1955-1959	21.9	4.1	1.8
Panama	1938-1959	...	...	...
	1949-1959	10.2	10.9	12.6
	1955-1959	13.7	16.1	10.9
Latin America	1938-1959	7.4 g/	6.5 g/	6.4 g/
	1949-1959	9.8 h/	7.9 h/	7.3 i/
	1955-1959	8.8 h/	10.3 h/	9.8 h/

Source: Direct information and publications prepared by ECLA.

Note: The figures in brackets are ECLA estimates.

f/ 1950-59.

g/ Includes seven countries: Argentina, Bolivia, Colombia, Chile, Peru, Venezuela, Mexico.

h/ Excludes: Haiti, Dominican Republic, British Guiana, West Indies, Surinam.

i/ Excludes: Brazil, Haiti, Dominican Republic, British Guiana, West Indies, Surinam.

/In view

In view of the fact that mining production - including iron, petroleum and sulphur to name the most dynamic - increased at an annual rate of only 5.9 per cent, both in the periods 1950-59 and 1955-59, the increased consumption of electricity in the past few years reflects the greater mechanization of industry and an increase in production in activities with the largest electric power inputs.

Figure IX shows the trend of industrial and mining electricity consumption in some countries per dollar of gross national product at 1950 prices. With the exception of Brazil and Chile, the curves show a marked increase in the consumption of electricity per unit of production.

On the other hand, the share of industrial and mining activities in total electric power consumption for Latin America as a whole shows a downward trend as a result of the more rapid increase in electric power consumption as an end use. The figure dropped from 65.6 per cent in 1938 to 62 per cent in 1949 and 54.9 per cent in 1959 (see again table 47).

The pattern of electric power consumption would thus seem to reflect the trend in the Latin American countries to give higher priority to achieving better living standards than to accelerating industrial and mining production; evidence of this can be seen in the fact that improvements in output per kWh have failed to make up for the decrease in the share of total consumption accounted for by mining and industry.

(a) Share of public electricity services in consumption by the manufacturing and mining industries

Generally speaking, it can be stated that the share of the public electricity services in the supply of electric power to the industrial sector is determined by the amount of electricity they are able to supply, for, with the exception of Uruguay where the public electricity service can meet the country's total electricity requirements, throughout Latin America there exist self-supply systems which could to a large extent be replaced. Only mining activities in places far removed from urban centres and some manufacturing activities which supplement industrial processes with the generation of thermal power can be considered marginal in relation to large-scale electricity supply at reasonable cost from public service networks.

/Figure IX

There is evidence to show that in a number of Latin American countries, any measure taken during the last twenty years to expand or reduce the growth of the public electricity service, quickly led to a reduction in the first case, and an expansion in the second, of power generated by self-suppliers.

For Latin America as a whole, the public electricity service supplied in 1959, 56 per cent of the electricity requirements of the industrial sectors already referred to. This denotes relative stabilization over the last five years (the figure was 55 per cent in 1955), but a marked increase over 1949 (only 46 per cent), in spite of the shortages referred to in chapter IV (see table 49).

In the first group (Uruguay and Argentina), the second group (Brazil, Mexico and Panama) and the third group (El Salvador and Guatemala), the public electricity service supplied the industrial sectors considered, in 1959, with a percentage equal to or higher than the above mentioned regional average.

(b) Incidence of industrial consumption on public electricity services

The industrial consumption supplied by the public electricity services in 1959 was 15,400 million kWh for the whole of Latin America, while the figures for 1949 and 1955 were 7,200 million and 10,400 million kWh respectively (see table 50).

Despite this growth - which implies an annual cumulative rate of 7.9 per cent over the last decade - there has been a decline in the share of industrial consumption in the public electricity service. After having accounted for nearly 47 per cent of consumption in the whole area in 1938 and 1949, it fell to about 40 per cent for the last years of the 1940 decade (see table 51). The explanation of this situation is similar to that given in the analysis of industrial and mining consumption as related to total electricity consumption; to this should be added the adverse effect of the restrictions which are frequently placed on industrial consumers, these restrictions being all the greater in view of the large amount of power they require.

This fall in the share of industrial consumption of electricity supplied by the public services would seem to be most pronounced in Argentina, Uruguay, Brazil, Bolivia and Paraguay. The contrary occurred to a marked degree, however, in Chile, Peru, Ecuador and El Salvador.

/Table 49

Table 49

LATIN AMERICA: SHARE OF THE PUBLIC SERVICES IN SUPPLYING ELECTRICITY TO THE MANUFACTURING AND MINING INDUSTRIES a/

(Percentages)

Country b/	1938	1949	1955	1959
First group				
Argentina	67.3	69.6	71.7	56.0
Cuba	...	32.8	48.3	50.7
Chile	12.4 c/	17.9	26.6	28.8
Uruguay	...	100.0	100.0	100.0
Venezuela	22.3	21.4	28.7	37.0
Second group				
Brazil	...	...	74.9	79.1
Colombia	60.3	49.1	47.8	45.3
Costa Rica	...	29.4 d/	34.0	50.0
Mexico	71.4	63.2	59.2	61.1
Panama	...	64.7	45.9	55.4
Peru	28.4 e/	23.4 e/	22.2 f/	24.4
Third group				
Bolivia	24.2	33.0	36.2	44.6
Ecuador	...	32.4 g/	37.5	47.5
El Salvador	...	43.6 d/	68.9	90.3
Guatemala	...	51.1 d/	52.2	55.8
Honduras	...	5.1 d/	11.9	13.7
Nicaragua	...	7.1 d/	16.3	20.0
Paraguay	...	41.2	53.8	54.5
Latin America	45.1	45.7	54.9	55.9

Source: Direct information and various publications prepared by ECLA.

a/ Information for other years appears in statistical annex "L".
b/ No information available for the countries not shown.
c/ 1940.
d/ 1950.
e/ 1952.
f/ 1954.
g/ 1951.

/Table 50

Table 50

LATIN AMERICA: INDUSTRIAL CONSUMPTION OF PUBLIC SERVICE ELECTRICITY a/

(Millions of kWh)

Country b/	1949	1955	1959
First group			
Argentina	1 677	2 275	(2 667)
Cuba	224	344	544
Chile	402	724	896
Uruguay	(235)	378	(439)
Venezuela	151	447	(934)
Second group			
Brazil	2 576	3 343	5 604
Colombia	193	393	(539)
Costa Rica	10c/	16	23
Mexico	1 402	2 013	(2 987)
Panama	11	17	31
Peru	180 d/	228 e/	(402)
Third group			
Bolivia	77	93	(112)
Ecuador	(11) f/	27	(56)
El Salvador	17 c/	31	65
Guatemala	24 c/	35	53
Honduras	2 c/	5	7
Nicaragua	5 c/	17	20
Paraguay	7	14	18
Latin America	7 204	10 400	15 397

Source: Direct information and various publications prepared by ECLA.

a/ Information for other years appears in statistical annexes "L" and "M".
b/ No information available for the countries not shown.
c/ 1950.
d/ 1952.
e/ 1954.
f/ 1951.

/Table 51

Table 51

LATIN AMERICA: INCIDENCE ON THE PUBLIC SERVICES OF INDUSTRIAL CONSUMPTION a/

(Percentages)

Country b/	1938	1949	1955	1959
First group				
Argentina	43.2	47.3	46.1	43.5
Cuba	...	31.6	28.8	29.2
Chile	38.4 c/	42.0	44.9	45.7
Uruguay	...	(52.0)	48.7	(45.4)
Venezuela	(37.5)	39.8	41.4	(40.0)
Second group				
Brazil	...	49.2	35.2	41.0
Colombia	23.3	24.5	27.1	(26.2)
Costa Rica	...	8.8 d/	7.7	7.5
Mexico	(54.2)	46.6	44.2	(44.2)
Panama	...	18.6	18.3	19.6
Peru	48.5 c/	46.5 c/	48.0 f/	(49.3)
Third group				
Bolivia	72.7	53.8	51.4	(47.2)
Ecuador	...	12.4 g/	17.4	(24.7)
El Salvador	...	32.7 d/	29.3	34.8
Guatemala	...	32.9 d/	32.4	31.7
Honduras	...	20.0 d/	27.7	21.9
Nicaragua	...	26.3 d/	41.4	27.4
Paraguay	...	36.8	35.9	32.1
Latin America	46.2	46.9	39.2	40.5

Source: Direct information and various publications prepared by ECLA.

a/ Information for other years appears in statistical annex "F".

b/ No information available for the countries not shown.

c/ 1940.

d/ 1950.

e/ 1952.

f/ 1954.

g/ 1951.

Chapter VI

MAIN ELECTRICITY SYSTEMS

The foregoing chapters contained a survey of the main features of the electricity economies of the Latin American countries. Particular attention was drawn to regional and national characteristics.

In order the better to understand the problems affecting electricity development, the basic functional unit should be considered at greater length. The unit concerned is the electricity system determined by a certain pattern of geographically localized demand, the satisfaction of which is attempted through a set of interconnected power stations.

There now follows a brief analysis of some of the main electricity systems in the different countries of Latin America, the purpose here being to illustrate, through a study of more or less representative examples, other aspects of the electricity industry not dealt with in earlier chapters or deserving of further attention in view of their economic importance for the region. These questions are:

(a) Distribution of electricity consumption within each country;
(b) Size of the systems and interconnexions;
(c) Percentage of hydro power in the systems and reserve capacity;
(d) Degre of uniformity in:
    (i) frequencies (number of cycles per second);
    (ii) transmission tension;
    (iii) the low tension distribution system;
(e) Variations in price per kWh, etc.

The main features of the various systems are shown in tables 52, 53 and 54.

It should be pointed out that although the per capita consumption figures presented in the tables and in general above national and regional averages, there are certain concentrations of demand which result from different causes. Thus, while the high consumption

/Table 52

Table 52

LATIN AMERICA: MAIN SYSTEMS, 1959

Country and System	Institution operating the system	Source of capital	Population supplied (millions of inhabitants)	Installed capacity: MW	Installed capacity: Percentage represented by public service	Installed capacity: Percentage of hydro power	Energy supplied: Millions of kWh	Energy supplied: Percentage represented by public service	Percentages of loss and unregistered consumption	Net per capita consumption (kWh)	Nominal reserve capacity (percentage) a/
Argentina											
Greater Buenos Aires System	(1) Servicio Eléctrico del Gran Buenos Aires, S.A.	Mixed	5.4	1 050	47.0	0.0	4 600	60.2	10.0	800	12
	(2) Compañía Italo Argentina de Electricidad, S.A.	Private									
	(3) Agua y Energía Eléctrica	Governmental									
Córdoba System	Empresa Provincial de Energía de Córdoba	Governmental	0.6	103	4.6	76.0	290	3.8	11.0	430	... b/
Bolivia											
La Paz-Oruro System	Bolivian Power Company, Ltd.	Private	0.5	62	80.3	99.0	221	78.6	15.2	353	19
Brazil											
Grupo Light System	Brazilian Traction and power Company	Private	7.8	1 700	48.0	86.0	10 500	56.0	12.2	1 180	0
State of São Paulo Power and Light System	Electric Bond and Share Company	Private	1.0	312	8.9	90.4	1 250	6.7	18.0	350	90
Minas Gerais System	Compañías Eléctricas de Minas Gerais (CEMIG)	Governmental	2.7	192	5.4	98.0	851	4.6	10.0	400	23
San Francisco System	Compañía Hydroelectrica de San Francisco (CHESF)	Governmental	2.8	200	5.7	90.0	710	3.9	...	223	28
Chile											
Interconnected System			5.3	559	98.0	79.0	2 175	96.0	12.0	570	33
	Cia. Chilena de Electricidad S.A. (CHILECTRA)	Private									
	Empresa Nac. de Electricidad, S.A. (ENDESA)	Governmental									
Colombia											
Bogotá System	Empresa de Energía Electrica de Bogotá	Municipal	1.1	128	20.0	88.0	600	22.2	10.0	500	2
Medellín System	Empresas Públicas de Medellín	Municipal	0.57	138	22.0	100.0	724	26.8	10.0	1 150	0
Ecuador											
Guayaquil System	Empresa Eléctrica del Ecuador	Private	0.04	35	40.0	0.0	114	45.0	7.0	250	41
Mexico											
Central System	Comisión Federal de Electricidad	Governmental	5.6	937	44.2	71.0	4 070	51.5	21.8	650	29
Peru											
Lima Area System	Lima Light and Power	Private	1.8	163	50.9	88.4	719	74.0	12.0	360	10
Uruguay											
Montevideo-Rincón System	Usinas y Teléfonos del Estado (U.T.E.)	Governmental	1.5	298	89.8	43.0	1 164	94.2	11.0	620	16
Venezuela											
Caracas System	La Electricidad de Caracas, Compañía Anónima	Private	1.2	341	40.0	4.3	1 187	42.4	15.0	840	30
Costa Rica c/											
San José System	Compañía Nacional de Fuerza y Luz	Private d/	0.27	38.5	56.5	74.0	226	76.9	19.0	677	...

Source: ECLA, on the basis of direct information and miscellaneous publications. a/ Installed capacity figures correspond to the rated capacity of units. No data on effective capacity were available. b/ No information on firm capacity was available. Hydroelectric power stations lack regulation works. c/ 1956. d/ This Company receives most of the current that it distributes from the State enterprise (I.C.E.).

/Table 53

Table 53

LATIN AMERICA: COMPOSITION OF CONSUMPTION AND AGGREGATE ANNUAL GROWTH RATE IN SOME OF THE MAIN SYSTEMS, 1950-59

(Percentages)

Country and system	Industrial	Household	Commercial	Transport	Other uses	Annual growth rate, 1950-59
Argentina						
Greater Buenos Aires System	32.2	35.2	11.9	...	20.7	5.5
Córdoba System	...	...	...	...	...	6.0
Bolivia						
La Paz-Oruro System	50.5 a/	35.4	12.3	...	1.8	3.6
Brazil						
Grupo Light System	42.4	17.2	14.9	6.4	19.1	10.0
State of Sao Paulo Power and Light System	28.8	21.7	11.8	...	37.7	
Mines Gerais System	74.8	2.5	1.3	...	21.4	...
San Francisc System	0.2	99.7	0.1	...	-	...
Chile						
Interconnected System	33.2	28.3	10.3	13.6	-	7.0
Colombia						
Bogotá System	30.5	28.9	27.1	1.7	11.8	12.1
Medellín System	24.4	55.8	7.2	...	12.6	10.0
Ecuador						
Guayaquil System	...	...	...	...	...	...
Mexico						
Central Interconnected System	52.1	15.8	17.4	2.8	11.9	10.0 b/
Peru						
Lima-Callao System	41.8	40.4	8.9	3.5	5.4	9.4
Uruguay						
Montevideo-Rincón System	45.4	39.0	9.3	3.3	3.0	8.3
Venezuela						
Caracas System	(40.0)	(60.0)	...	...	...	16.9
Costa Rica						
San José System	...	...	...	...	...	10.6 c/

Source: ECLA, on the basis of direct information and miscellaneous publications.

a/ Including consumption in mines.
b/ 1954-59.
c/ 1950-56.

/Table 54

Table 54

LATIN AMERICA: FREQUENCIES AND TENSIONS USED IN SOME OF THE MAIN SYSTEMS, 1959

Country and system	Frequency (cycles per second)	High-tension voltage (kV)	Low-tension triphase distribution (V)
Argentina			
Greater Buenos Aires System	50	132; 66; 27.5; 20; 13.2; 12.5; 6.8; 6.5	390/220 (4 conductors 225 (3 conductors) 450 (3 conductors) 220/440 (3 conductors)
Córdoba System	50	66; 25; 13.2; 10; 6.6	380/220 (4 conductors) 320 (3 conductors)
Bolivia			
La Paz-Oruro System	50	66; 38;13	115/200(4 conductors) La Paz 220 (3 conductors) Oruro
Brazil			
Grupo Light System	50 in Rio de Janeiro 60 in Sao Paulo	...	125/216 (4 conductors)R.J. 115/220 (4 conductors)S.P.
State of Sao Paulo Power and Light System	60	132; 66	127/220 (4 conductors)
Minas Gerais System	60	161; 138; 69; 44 34.5; 22; 13.8	...
San Francisco System	60	220; 132; 13.8	220/380 (4 conductors) 127.220
Chile			
Interconnected System	50	154; 110; 66; 44; 13.8	220/380 (4 conductors)
Colombia			
Bogotá System	60	57.5; 30; 20; 11.4	150/260 (4 conductors)
Medellín System	60	120	120/208 (4 conductors)
Ecuador			
Guayaquil System	60	13.2; 4.1	208/120 240/120
Mexico			
Central Interconnected System	50	220; 150; 83; 60; 44; 20; 6	...
Peru			
Lima-Callao	60	64; 30	220 (3 conductors)
Uruguay			
Montevideo-Rincón System	50	150; 110; 60; 30	220 (3 conductors)
Venezuela			
Caracas System	50	230; 69; 30; 4.8/8.3	120.208 (4 conductors) 240 (3 conductors)
Costa Rica			
San José System	...	33; 13.2; 4.16; 2.4	...

/rates in

rates in São Paulo, Rio de Janeiro and Buenos Aires can be explained by the considerable degree of industrialization and the high income levels of the population served, the substantial volume of consumption in Caracas is due chiefly to the latter factor, and that registered in Medellín and San José de Costa Rica to the extremely low price of electric power and the active encouragement given to its use for domestic purposes.

The case of Buenos Aires also shows how the severe restrictions on industrial and household consumption which have been in force for the last ten years bring down consumption levels which would have been much higher in the absence of rationing. Variations in the distribution pattern for consumption as between industrial and household use indicate the differing degrees of importance attached to development in the systems considered. Special mention should be made of the Grupo Light in Brazil and the central interconnected system of Mexico, where the preponderance of industrial consumption reflects the impressive development of the industrial sector in recent years. There follows a summary of the conclusions which may be drawn after consideration of the foregoing aspects of the general picture.

1. Distribution of electricity consumption within each country

The consumption of electricity (kWh/per capita) is very unevenly distributed within each country. While in the main population centres and certain industries with a heavy input of electricity (mines, sugar factories, etc.), the per capita power supply is large. There are smaller towns and wide rural areas which have no electricity for lack of means of supply, or because demand is scanty and scattered. In 1959, there were systems in which net consumption per capita was above 800 and even as high as 1 000 kWh, while large areas within the same countries consumed less than 50 kWh per capita (see figures X and XI).

Within the principal systems, the break-down of consumption by types of consumer does not differ very much in any instance from the average pattern recorded for the public electricity services in each country. This is to be expected in view of the preponderant influence

/Figure X

of the systems in question on the national total. It is, however, possible that on the whole there is proportionately a slightly higher incidence of electricity consumption as an end use than as a factor in production (see table 53).

2. Size of electricity systems and interconnexions

In many countries, the main electricity systems have developed in complete isolation round capital cities and other major towns. In other countries, however, this stage is already being left behind. In this respect, Chile is in the forefront of the Latin American countries. The "interconnected system", as it is called, which already covers 6.5 degrees of latitude - and will later cover 12 degrees -, included, in 1959, 98 per cent of the installed capacity of the public services and accounted for 96 per cent of their production. Throughout the system, large-scale transfers of power are effected, use being made of the various hydrological régimes and storage capacities - partly natural - to be found up and down the country. In Uruguay, in 1958, the Montevideo-Rincón del Bonete system accounted for 94.2 per cent of the energy generated by the public services, combining thermal generation in Montevideo with hydro-electric generation at the first Rio Negro plant. In Brazil, the system serving the Rio de Janeiro and São Paulo areas, which in 1959 already generated 56 per cent of the output of the country's public services, is partially interconnected with the Sistema Paulista de Força e Luz (State of São Paulo Power and Light System). Work is being carried out on the Furnas-Peixoto, Furnas-São Paulo and Furnas-Belo Horizonte lines, with a view to permitting their interconnexion with the Minas Gerais system (CEMIG) and, consequently, the more efficient utilization of various water régimes in the southern part of Brazil's central zone. This interconnected system also includes thermal power stations, and within a few years it will probably boast a nuclear power station. Approximately 65 per cent of Brazil's consumption will then be concentrated in the system in question.

/The rate

The rate of growth of the systems under review is much the same in each of the countries as for the public services as a whole. There are, however, cases - like Buenos Aires and Caracas - where the rate of growth is slower, and others - such as the central interconnected systems of Mexico, Bogotá and Montevideo - where it is higher.

3. Reserve capacity

The reserve capacity of the majority of the systems considered would seem to be in the neighbourhood of 10 to 20 per cent. As already stated several times, however, it should be stressed that this is a nominal figure based solely on power ratings. Such figures are frequently far from accurate, owing to wear and tear on equipment and because firm capacity in run-of-river power stations is usually lower. If account is taken of the annual rate of increase of demand, it may be concluded that, with few exceptions, there are practically no reserves, and this means that rationing is frequent, particularly during peak hours; it is, however, applied in various different ways.

As to supply, broken down by type of source, in most systems hydroelectric and thermal production are combined, the former predominating. Exceptions are Buenos Aires, Caracas [1/] and Guayaquil, where electricity is generated purely by thermal means. In such cases the tendency is for the hydroelectric power stations to appear at the base of the load diagram, despite the fact that those which have storage facilities also operate at peak loads.

4. Frequencies

In Latin America direct current is to be found only on some small systems of slight importance, the use of alternating current being more usual.

In the majority of the Latin American countries, some systems operate on 50 cycles per second and others on 60 cycles. This is a serious problem, which not only affects users as a result of the changes they have to make in their electric appliances and equipment on moving them from one system to another with a different frequency,

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1/ In Caracas production of hydroelectricity is on a very small scale, and is being suspended, at least in part.

/but is

but is also a grave hindrance to the interconnexion of systems. As time goes by, this problem will become still more serious, and harder to solve. Failure to deal with it immediately will seriously restrict the integration of networks, with all the economic consequences resulting therefrom.

In Brazil and Venezuela this factor already carries a great deal of weight in electrification plans. In both countries 60 cycles has been adopted as the standard frequency. In the meantime, while the standardization of frequencies is being carried out, some generating units capable of operating at both frequencies, or transformers, are being installed in the main systems, which operate at 50 cycles. This increases the cost of generation.

5. Transmission voltages and low utilization voltages

The great range of high voltages used in the various countries, and even within single systems (with a few exceptions) makes any attempt at classification fruitless. Low utilization voltages also vary considerably.

Although neither of these problems is as serious as that of differences in frequency, standardization should be introduced in each country, to facilitate interchangeability of parts and reduction of spare-part inventories, and in the region as a whole, in order to place industrial production on a normal footing.2/

6. Electricity price trends

With the inflation that has prevailed in varying degrees throughout Latin America in recent years, electricity prices have been gradually increasing, but very slowly, and substantially less than the prices of most other goods and services. This has considerably weakened the financial position of many electricity enterprises, and consequently has reduced the possibilities of expanding the systems they operate.

2/ See Internationsl Electrotechnical Commission (IEC), publication N° 38, IEC Standard System Voltage.

/Calculation of

Calculation of the ratios between the average kWh price indices and the cost of living for 1959 (100 = 1938 or some other year for which the relevant information is available) gives values of much less than unity for the systems examined (with one exception). This indicates how far electricity prices have lagged behind others in the Latin American countries.

To show the possible margin for substitution of public-service electricity for other fuels in certain industrial activities, table 55 presents, for each of the various systems, the average prices equivalence for the industrial consumer as between 1 000 kWh and certain fuels such as coal, petroleum and derivatives. The figures differ widely from one system to another, even within a single country. This indicates the inconsistency, and in some cases the complete absence of national price policies for the power sector and for its various components.

The annex which follows gives an account - as detailed as the available data permit - of the main characteristics of some of the principal Latin American systems.

/Table 55

Table 55

LATIN AMERICA: COMPARATIVE PRICES PER KWH IN SOME OF THE MAIN SYSTEMS, 1959

Country and system	Relation between price indices (kWh/cost of living)	Price equivalences for 1 000 kWh industrial energy (averages)
Argentina		
Greater Buenos Aires System	1950 = 1.00 1959 = 1.06	1.83 tons of fuel oil 1.28 tons of diesel oil
Córdoba System	1938 = 1.00 1958 = 0.52	0.48 tons of fuel oil 0.33 tons of diesel oil
Bolivia		
La Paz-Oruro System	1938 = 1.00 1959 = 0.38	0.55 tons of diesel oil
Brazil		
Grupo Light System	...	0.26 tons of diesel oil 0.70 tons of coal
State of Sao Paulo Power and Light System	...	0.25 tons of diesel oil 0.61 tons of coal
Minas Gerais System	...	...
San Francisco System	1955 = 1.00 1958 = 0.49	...
Chile		
Interconnected System	1938 = 1.00 1959 = 0.60	0.35 tons of fuel oil 0.215 tons of diesel oil
Colombia		
Bogotá System	...	0.2 tons of diesel oil 0.36 tons of fuel oil
Medellín System	...	0.175 tons of diesel oil 0.300 tons of fuel oil
Ecuador		
Guayaquil System	1940 = 1.00 1959 = 0.52	...
Mexico		
Central Interconnected System	1934 = 1.00 1958 = 0.23	0.5 tons of fuel oil 0.7 tons of coal 1.3 tons of diesel oil
Peru		
Lima-Callao System	1950 = 1.00 1959 = 0.83	0.66 tons of coal 0.49 tons of diesel oil 0.57 tons of industrial petroleum
Uruguay		
Montevideo-Rincón System	...	...
Venezuela		
Caracas System	1949 = 1.00 1959 = 0.74	0.29 tons of fuel oil 0.46 tons of diesel oil
Costa Rica		
San José System	1952 = 1.00 1959 = 1.15	...

ANNEX

A brief general description of the electric power and economic characteristics of some of the main systems in Latin America has been attempted in Chapter VI. Its preparation required a number of detailed analyses of these systems, representative of different conditions in the structure of energy demand and supply and, in the case of those which were studied, their operation, the characteristic load curves, the use of the plants, etc.

These studies could not be presented in full for lack of time and they therefore had to be restricted to the brief reference made here. The geographical location of the systems can be found on the maps of the countries concerned.

I. ARGENTINA

1. Greater Buenos Aires system

Argentina's major electricity system is the one which serves the Federal capital and the densely populated areas within its radius of influence. The system consists of the installations of the Servicios Eléctricos del Gran Buenos Aires S.A. (SEGBA), the Compañía Italo Argentina de Electricidad S.A. (CIAE) and, from the interconnexion with the San Nicolás thermal plant, the Empresa del Estado Agua y Energía Eléctrica. CIAE and SEGBA supply energy to the Federal capital, with SEGBA extending its networks to the areas which form the southern zone of Greater Buenos Aires (Almirante Brown, Avellaneda, Berisso, Cañuelas, Coronel Brandsen, Ensenada, Esteban Echeverría, Florencio Varela, Lanús, La Plata, Lomas de Zamora, Magdalena, Quilmes and San Vicente). Agua y Energía Eléctrica serves the north-west zone (General Las Heras, General Rodríguez, General San Martín, General Sarmiento, La Matanza, Marcos Paz, Merlo, Moreno, Morón, Pilar, San Fernando, San Isidro, Tigre and Vicente López).[1/] These areas cover some 13,000 km^2 and include a population of about 6.4 million, slightly more than 30 per cent of the country's total population. The system nevertheless supplies electricity to only 5.4 million inhabitants because of the existence of a few lesser services and the fact that some villages have no electricity.

The area covered by the system includes a substantial concentration of important industries (textile, food processing, chemical, paper, etc.) and is a centre of financial and commercial activity. Agriculture is an important activity in the rural areas.

The demand for electricity has developed abnormally because of the lack of generating plants and the resulting administrative restrictions. Energy is supplied exclusively by thermo-electric plants.

1/ The temporary interconnexion with Rosario is omitted since this report applies only to the province of Buenos Aires.

/Net per

Net per capita consumption through public utilities within the system amounted to some 800 kWh in 1959. However, self-generation is high in the area (1.1 million kW with 300 MW capacity) and total per capita consumption is thus estimated to have reached 950 kWh. (The national per capita average output was 374 kWh through public utilities and 476 kWh in all).

During the period 1950-59 consumption increased at an annual cumulative rate of slightly more than 5.5 per cent, as compared with a population growth rate of 2.3 per cent.

Maximum overall load measured at the generating plants amounted to approximately 940 MW (1959). It is estimated that the network drop and other restrictive measures at peak hours reduced the actual maximum load by at least 200 MW. This figure does not include the additional potential load represented by pending applications for new connexions and extensions.

(a) Characteristics of consumption

The restrictions imposed for many years on service, particularly at peak hours, have substantially altered the characteristics of demand. These include, for instance, the restriction that consumers must not use more electricity than they did in 1949. Factories which are only supplied by public utilities are thus compelled to shut down production one day a week, and the use of electricity in new buildings for heating, air conditioning and cooking is severely curtailed.

Consumption by type of consumer was approximately as follows: domestic - 35.2 per cent, commercial - 11.9 per cent, industrial - 32.2 per cent and government - 20.7 per cent.

The annual cumulative growth for the types of consumption mentioned above was more or less as follows for the period 1949-59: domestic - 8.4 per cent, commercial - 6 per cent, industrial - 3.3 per cent, government - 4.4 per cent, transport - 1.7 per cent. These figures reflect the severe restrictions imposed on the industrial sector which, as a result, has had to resort extensively to self-generation.

In terms of the total for the principal consumers supplied by public utilities throughout the country, the system accounts for the following

/percentages per

percentages per type of consumer: domestic and commercial - 55, industrial - 57, public lighting - 38 and transport - 72. (These figures merely provide an order of magnitude since they were drawn from widely varying sources of information).

Moreover, it is estimated that maximum demand by type of consumer, expressed in percentages, is as follows: domestic - 61.6 per cent, commercial - 5.3 per cent, industrial - 16.2 per cent and government - 16.9 per cent.

The load factor in a winter working day (July) for the SEGBA network was about 0.7 and the average seasonal variation in demand is about 15 per cent between winter and summer. The annual load factor has slowly increased from 0.44 in 1938 to 0.56 in 1959.

(b) Installed and generating capacity

Electricity generated amounted to approximately 4,600 million kWh (1959) with an annual load factor of 0.56. The system contributes about 51 per cent of the total for the country as a whole.

The system's nominal generating capacity was nearly 1,300 MW, with actual capacity amounting to only 1,060 MW. These figures represent about 56 per cent of the total for the country as a whole.

Moreover, since of the three companies mentioned only Empresa Agua y Energía Eléctrica generates electricity beyond the limits of Greater Buenos Aires (San Nicolás plant), the zone represents 42 per cent of the generating capacity and 50 per cent of the electricity supplied by public utilities in Argentina (1959).

With respect to generating capacity, the three companies contribute to the system as follows: SEGBA - 57.5 per cent, CIAE - 22.1 per cent and Agua y Energía Eléctrica - 20.3 per cent.

(c) Plants and lines

Generating capacity which, as already stated, is purely thermal, is summed up in the following table:

/Owner

Owner	Plant	Nominal Capacity (MW)	Actual Capacity (MW)	Year of Installation
SEGBA	Puerto Nuevo	315	300	1928-49
"	Dock Sud	318	245	1913-54
"	Ribera Este	30	8	1921-26
"	Paternal	14	7	1931
"	Berisso	16	9	1910-30
CIAE	Nuevo Puerto	166	154	1933-52
"	P. Mendoza	96	63	1919-51
A y EE	San Nicolás	320	270	1954-56
Total		1,275	1,056	

The San Nicolás plant feeds about 200 MW into the system and the remainder to the city of Rosario and adjacent areas. Thus, the maximum demand supplied was practically equal to the actual capacity (1959), an indication of the serious crisis which the system is undergoing and which has to some extent limited the development of the area for several years.

The different companies constituting the system and the age of the installations explain the lack of uniformity in the characteristics of the lines and networks. At present the following voltages are used: 132, 66, 27.5, 20, 13.2, 12.5, 6.8 and 6.5 kV. The two lines linking San Nicolás to Greater Buenos Aires (Morón) are 132 kV lines.

Power is generated at a frequency of 50 cycles per second, with the exception of Ribera Este where the frequency is 25 cycles.

Distribution at low tension is chiefly of the three-phase type at 390/225 volts with four conductors (SEGBA and A y EE) and at 225 volts with three conductors (CIAE). However, there are also 450 volt circuits (3 conductors) and 224/440 volt (3 conductors) direct current lines. The technical and economic problems arising from lack of uniformity in the characteristics of the system and the advantages of standardization are well known.

/(d) Works

(d) Works under construction and in the project stage

SEGBA's immediate programme provides for the installation of a 140 MW turbo-generator at Puerto Nuevo which is to start operating in 1961, three 24 MVA and one 36 MVA sub-stations, a 132 kV aerial power line for 120 MVA up to La Plata and some 160 km of underground high-tension wires, as well as a large increase in distribution networks for more than 100,000 new consumers. The estimated cost of this programme is about 75 million dollars (27 per cent in foreign exchange and the rest in national currency). It is being financed through loans from the Export-Import Bank and credits from the foreign suppliers of equipment and materials. National currency requirements will be met through reinvestment of replacement funds, profits, the issuing of bonds on the domestic market and contributions from the State.

For its part, CIAE hopes to reach an agreement with the authorities on rates which would enable it to carry out its plans to expand and replace installations. It intends to expand the plant at Nuevo Puerto and to build four main sub-stations.

Agua y Energía Eléctrica is building the "Central Termoeléctrica Gran Buenos Aires" (or "Nuevo Dock Sud") at the mouth of the Riachuelo river, which will have a nominal capacity of 600 MW (4 x 150 MW). The foundations have caused some difficulty and this will delay, probably until 1963-64, the staggered entry into operation of the units concerned. There has also been some difficulty with the proposed investment programme, which is to be refinanced. The strengthening of the network in the north-west part of the Federal capital by means of new cables and the installation of a number of transformers is also provided for.

Also under consideration is the installation of eight 132 kV sub-stations.

In June 1960 two firms of engineering consultants (Tippetts-Abbett-McCarthy-Stratton and Kennedy & Donkin) submitted to the Argentine Government a report entitled "Survey of Electricity Problems in Argentina" for which they had been contracted in 1959. With respect to the Greater Buenos Aires

/system their

system their recommendation for the period up to 1969 does not provide for a separation of this system from the rest of the coastal area. It calls for a total investment of 501 million dollars (48 per cent in foreign exchange and the balance in national currency), divided as follows: generation - 223 million dollars (69 per cent in foreign exchange), transmission - 80 million dollars (50 per cent in foreign exchange), distribution - 198 million dollars (23 per cent in foreign exchange).[2/] Required capacity is estimated at 2,795 MW in 1969 (including a 15 per cent reserve), which means that 1,250 MW would have to be installed. Available capacity would be 2,769 MW, drawing 59 MW from Ribera Este, Berisso, Paternal and several diesel plants.

(e) Evolution of energy prices

The evolution of the average price per kWh in Buenos Aires (CIAE) may be determined from the following indices, with 1950 being taken as the basic index of 100. The first figure for each year is that of the cost of living and the second is the price per kWh: (1950) 100 and 100; (1953) 195 and 178; (1956) 257 and 239; (1958) 423 and 366; (1959) 905 and 955.

As in indication of the cost of possible industrial use of other forms of energy, it is estimated that the average price of 1,000 kWh in the system (CIAE) in 1959 was equal to the sales price of 1.83 tons of fuel oil and 1.28 of diesel oil.[3/]

2/ Expenditure in connexion with plants under construction, such as the Dock Sud plant, has not been included.

3/ In additon to direct data from SEGBA, CIAE and A y EE, the following publications were consulted: Plan Eléctrico Nacional 1959 (Department of Water and Electric Energy; Electrificación Provincial - Province of Buenos Aires (Ministry of Public Works); Survey of Electricity Problems in Argentina (Tippetts-Abbett-McCarthy-Stratton and Kennedy & Donkin), and the Boletín estadístico de electricidad, 1957 (National Department of Energy and Fuel).

2. System of the Empresa Provincial de Energía de Córdoba (EPEC)

This system is owned by the State concern which supplies the city of Córdoba and the surrounding areas.[4] Since 1959 the installations owned by the former SUDAM and ANSEC groups have been incorporated into the system. In the same year the combined maximum load of the generating plants amounted to 63 MW, with about 290 million kWh being supplied to consumers. These figures represent, respectively, 2.8 and 3.8 per cent of installed capacity and electricity output provided by the country's public utilities.

These centres comprise some 600,000 inhabitants divided into about 100,000 households. Actual per capita consumption exceeded 430 kWh and was marked by an easing of restrictions and rationing during the past few years.[5] The annual cumulative increase in generation in the period 1950-59 amounted to only 6 per cent. Since the population growth was only 2 per cent this increase can be partly attributed to the incorporation of populated centres formerly served by other companies.

The production breakdown was as follows: 28 per cent by plants owned by EPEC, most of which are hydraulic, and 72 per cent by the hydraulic plants of the Empresa del Estado Agua y Energía Eléctrica.

The main plants feeding this inter-connected system are: Los Molinos (I and II) 55 MW, Río Tercero II-16 MW, and Río Primer-7MW, all of these being hydraulic plants, the 10 MW Dean Funes steam plant, and the 10 MW Mendoza and 5 MW Las Playas internal combustion plants. It is interesting to note that of the 103 MW installed capacity, available firm capacity in 1959 was 62 MW or only 60 per cent. The annual load factor amounted to 0.52.

4/ Some of the main populated centres served are: Villa María, San Francisco, Villa General Mitre, Río Cuarto, Bell Ville, San Roque, James Graik, etc.

5/ Not included in the system is a consumption of 60 million kWh by military establishments supplied by the 10.8 MW Río Tercero I hydraulic plant, which would raise average per capita consumption to 530 kWh a year.

/In the

In the previous year it was 0.50, so that the total plant factor barely exceeded 25 per cent, of which 22 per cent was represented by the combined hydraulic plants, notwithstanding the fact that 1958 was not a particularly dry year.[6/] The load factor during the past 20 years varied as follows: 0.40, 0.48 and 0.52 in 1938, 1949 and 1959 respectively, reflecting the increase in industrial consumption in the area, in spite of the fact that consumption by military factories, with a load factor of 0.63, is not included in the system. The load factor in a typical winter work day was over 0.61. It should be pointed out that the flow of the rivers in the area varies considerably in the course of the year, the lowest point being reached during the months of maximum electricity demand (June to September). This calls for extensive storage regulation if water resources are to be used efficiently. The seasonal variation of average demand is about 10 per cent between summer and winter.

In 1958 the Córdoba system received 166 million kWh from A y EE (Río Tercero and Los Molinos), while it transmitted 10 million kWh to the Sierras area and 17 million kWh to Villa María, Ballesteros, Carcano, Morrison, Villa Nueve and James Graik. High and medium tension voltages used are 66, 25, 13.2, 10, 6.6, 5, 4, 3.3 and 2.2 kV, while low-tension voltage is distributed at 3 x 380/220 (4 wires) and 3 x 320 (3 wires) at 50 cycles. Some sectors have 60 cycle and others direct current grids. Standardization at a reduced number of voltages and the use of a single frequency would clearly be of positive advantage from a technical and economic point of view.

Plants under construction by Agua y Energía which will increase the hydro-electric supply of the system are: San Roque in Río Primero - 24 MW (1960), La Viña I - 16 MW (1960) and Río Tercero III - 33 MW (1964).[7/] For

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6/ While reserve mechanical capacity was high (75 per cent), firm capacity was barely 5 per cent higher than maximum demand. In other words, it was less than the average annual growth rate (6 per cent).

7/ It is estimated that these plants will generate approximately 130 million kWh a year, which means a plant factor of only 21 per cent. Construction of a reservoir at San Roque, which would increase that plant's output by 20 million kWh, is envisaged. Other plans for the provision of new regulating reservoirs would improve the use of existing plants without impairing irrigation facilities.

its part, EPEC has a major expansion plan through which new sources of energy will be made available to a large part of the province. According to this plan, 550 million kWh and 155 MW will be supplied in 1965. Other EPEC projects include the installation of a thermal plant of approximately 30 MW (1961), the construction of 230 km of 132 kV lines, 280 km of 66 kV lines and 131 km of 33 kV lines, in addition to the corresponding 13.2 kV and low-tension grids. The cost of the entire scheme is estimated at about 3,000 million Argentine pesos. The necessary financing arrangements have already been made.

The development of the average kWh price within the system, in terms of the cost of living, may be gauged from the following indices, with the base index of 100 being applied to 1938. The first figure is that of the cost of living,[8] and the second relates to the price per kWh:[9] (1938) 100 and 100, (1949) 267 and 180, (1955) 772 and 594, and (1958) 1,430 and 750. It will be noted that the average price of electricity seems to have dropped by nearly 50 per cent, compared with the cost of living, during those 20 years.

8/ U.N. Monthly Bulletin of Statistics.

9/ Empresa Provincial de Energía de Córdoba.

II. BOLIVIA

1. Systems of the Bolivian Power Company Ltd.

The Bolivian Power Co. Ltd., a private firm financed with Canadian capital, has two systems in Bolivia which are not connected. One supplies La Paz and Viacha and the other serves Oruro in addition to the large mining areas in the departments of Oruro and Potosi. The population of La Paz and Viacha is about 395,000, of whom approximately 95 per cent are supplied with electricity in their homes. The Oruro system, including the mining population, supplies some 235,000 inhabitants. The two systems will be considered together in view of their geographical proximity and the nature of the data available.

Net per capita consumption in 1959 was somewhat in excess of 350 kWh, compared with 110 kWh for the rest of the country. Annual cumulative growth was as follows: 7.2 per cent in the period 1939-59, 5.3 per cent in 1949-59 and 6.6 per cent in 1954-59.

The maximum load achieved in the generating plants in 1959 was 52 MW.

(a) Characteristics of consumption

The inadequate structure of existing rates and the restrictions imposed on supply have resulted in the following percentage figures by type of consumer in 1959: domestic 35.5, commercial 12.3, industrial 15, mining 35.5 and public lighting 1.8.

If mining consumption is excluded, the breakdown of urban consumption is as follows: domestic - 58 per cent, industrial - 19 per cent, commercial - 16 per cent, miscellaneous - 7 per cent.

While industrial consumption has declined in the past few years, domestic consumption has increased at an annual rate of more than 8 per cent (1949-59). The low cost of domestic consumption encourages waste and misuse of electricity. In fact, 46 per cent of urban consumption is used for heating (household heating, cooking, bath-heating, ironing, etc.) and only 19 per cent for production.

The equivalent annual load factor was 0.54.

(b) Installed

(b) Installed and generating capacity

Total output amounted to 247 million kWh in 1959. The two systems thus provided some 58 per cent of the country's total output and 78.6 per cent of the output by public utilities.

Available firm capacity was 62 MW, while maximum load amounted to 51.8 MW (1959). The maximum load for the La Paz system will exceed the firm capacity as from 1961, with rationing being restored in low-water periods. This will have to be done for several years since there is no new plant under construction at the present time.

Generating capacity is completely hydraulic for La Paz and 98 per cent hydraulic for Oruro.

(c) Plants and lines

The following are the plants in each system:

Name	Type	Capacity (kW)	System
Achachicala	Storage	5,000	La Paz
Zongo	"	4,600	"
Botijlaca	Run-of-river	3,600	"
Cuticucho	" "	8,200	"
Santa Rosa	" "	9,900	"
Sainani	" "	9,500	"
Miguilla	Storage	3,700	Oruro
Angostura	"	4,100	"
Choquetanga	Run-of-river	7,000	"
Carabuco 1	" "	6,000	"
Oruro	Diesel	440	"
		62,040	

In 1959 the plant factor was 46 per cent in La Paz and 49 per cent in Oruro. The frequency used by both systems, as well as by the other major systems in the country, is 50 cycles per second.

Transmission voltages used are 66, 38 and 13 kW. Plans for interconnexions at 110 kV are under serious consideration as a result of the "corona effect" produced by the altitude above sea level at which these

/lines are

lines are strung and the conditions of dampness and stormy weather prevalent during the summer months.

The low-tension distribution system is of the three-phase 115/200 V type for La Paz and the three-wire 220 V type for Oruro.

(d) Future activities

The company which has the concession is negotiating with the authorities for an adjustment of rates and an agreement on the method of payment in respect of the demand by the Corporación Minera de Bolivia (COMIBOL).

Pending these agreements, not a single plant is now under construction in spite of the fact that demand has already exceeded firm capacity at La Paz. A critical stage will also be reached very shortly at Oruro.

Studies have nevertheless reached an advanced stage in connexion with the construction of the 22 MW Chururagui plant for the La Paz system. The plant is to be built on the Zongo river, where the other plants are situated. There is also a project to build a 6.2 MW plant, to be called Carabuco 2, for the Oruro system. Plans have also reached an advanced stage for the interconnexion with the Cochabamba system where a 32 MW plant on the Corani river is to be built later by the Bolivian Development Corporation.

(e) Evolution of energy prices

The average price per kWh of electricity has developed in accordance with the following indices:

	1938	1948	1958	1959
Cost of living	100	533	58,500	70,300
Price per kWh	100	265	26,100	26,800

Thus, the price of electricity has failed to keep pace over the years.

As an indication of the cost of possible substitution by other sources of energy, it is estimated that the cost of 1,000 kWh in La Paz (1959) was equal to the sales price of 0.24 tons of diesel oil.[10/]

10/ The data for this section was obtained directly from the Bolivian Power Co. Ltd., and from studies made available by the National Planning Board and the Bolivian Development Corporation.

III. BRAZIL

1. Light group systems

The two main electricity systems in Brazil supply the area of the former Federal Capital and the area of the capital of the State of São Paulo, in addition to extensive areas in the Paraiba valley. These systems belong to what is known as the Light Group, made up of subsidiaries of a Canadian firm, the Brazilian Traction, Light and Power Company of Toronto. They are interconnected by a 230 kV line 332 kilometres long, extending from between the Nilo Peçanha (State of Rio de Janeiro) and Cubatao (São Paulo). Carrying capacity is about 200 MW. In 1959 the maximum demand at the generating stations was about 1,800 MW, which was about 100 MW more than installed capacity, with a total production of 105 million MWh. These two figures represent 51 per cent and 56 per cent respectively of the installed capacity and total production of the main public service enterprises in Brazil.

The estimated population in the municipal centres in the territory covered by these systems was 7.8 million.[11/]

In the area supplied by these systems there is an appreciable concentration of important industrial activities (metallurgical industries, manufacture of machinery and electrical equipment, steel, chemical, textile, food and paper industries, etc.) and commercial and financial activities. In addition there is considerable agricultural activity in the rural areas.

(a) Consumption trends

Net annual per capita consumption in the area (excluding distribution losses and unmetred consumption) rose from 950 kWh in 1950 to 1,180 kWh in 1959. To meet this increase production grew at an annual cumulative rate of nearly 10 per cent during this period, despite the restrictions imposed in various years, compared with a demographic growth rate of approximately 4 per cent. In 1959 the average annual per capita net consumption for the country as a whole was 327 kWh.

11/ According to the information given in Plano Nacional de Eletrificação e Centrais Eletricas Brasileiras, S.A., Presidencia da República.

/For the

For the same year consumption by type of consumer was as follows: domestic 17.2 per cent; commercial 14.9 per cent; industrial 42.4 per cent; rural consumption, public lighting and public authorities 19.1 per cent, and transport 6.4 per cent.

The consumption in the two systems by type of consumer in 1959 represented the following percentages of the total consumption for the public service for the country as a whole: domestic 51.2 per cent, commercial 64.3 per cent, industrial 68.9 per cent and other 67.2 per cent.

(b) Companhia São Paulo Light S.A.

This company's concession covers an area of 20,000 square kilometres with over 4 million inhabitants and has over 800,000 registered consumers (5 inhabitants per registration). It is the largest system from the standpoint of power generated and consumption; in 1959 production amounted to 6.4 million MWh, of which 74.5 per cent represented the Cubatao Hydro-electric plant, 21.2 per cent the Piratininga thermal plant, and the balance other plants.

The maximum hourly demand was 1,098 MW, giving an annual load factor of 0.66. Losses amounted to 12.2 per cent.

In 1959 consumption by type of consumer was as follows: industrial 48.2 per cent, domestic 14.6 per cent, commercial 11.6 per cent, transport 8.3 per cent, public authorities 3.3 per cent, public lighting and others 1.1 per cent and transmissions to other enterprises 12.9 per cent. The activities requiring the highest annual power increases, expressed in millions of kWh for 1958-59 were: steelworks and iron foundries 90.5, chemical industries 7.13, textiles 41.0, automobiles 28.3, lubricants 18.3 and manufacture of electrical equipment 17.5.

(c) Plants and methods of distribution

The power generated by the Light Group as a whole is mainly hydraulic (over 85 per cent in 1959), as can be seen from the following list of plants supplying power:

/Plant

	Plant	Type	Capacity (MW)	Date when the machinery was installed
Rio area				
	Fontes	Hydraulic	154	1908-47
	Nilo Peçanha	Hydraulic	330	1953-54
	Ilha dos Pombos	Hydraulic	162	1924-49
São Paulo area	Cubatao	Hydraulic	734	1926-56
	Porto Goes	Hydraulic	11	1928
	Rasgao	Hydraulic	18	1925
	Itupararanga	Hydraulic	56	1914-25
	Piratininga	Thermal	200	1954

The Nilo Peçanha, Fontes, Cubatao and Itupararanga plants are linked to large reservoirs representing a total storage capacity of some 2,500 million kWh. The Billings, Guarapiranga, Edgard de Souza and Pirapora reservoirs are provided with three pumping stations for supplying the Cubatao plants (underground and exterior) with a gross head of nearly 719 metres. This constitutes a significant and well-conceived example of hydroelectric exploitation by reversing the direction of the runoff in the river valley (in this case the river Tieté valley).

While the Rio de Janeiro system operates on 50 cycles, the São Paulo system uses 60 cycles, and the interconnexion is made through transforming stations at Aparecidas (São Paulo) and Rio de Cidade (Rio de Janeiro). This difference in frequency is a serious problem which shows the technical and economic necessity of standardizing the characteristics of the systems (frequencies, voltages and methods of distribution). Pending the taking of such measures, some generating plants have been designed to operate on both 50 and 60 cycles.

In Rio de Janeiro the domestic distribution is triphase with four wires, and the nominal voltages are 125/216. The system is the same in São Paulo, except that the nominal voltages are 115/220.

/(d) Projects

(d) Projects under construction and at the planning stage

The following projects are under construction, to meet the rapidly increasing demand: in the São Paulo area, expansion of the Cubatao (underground) plant with two addition units of 65 MW each (1961); expansion of the Piratininga plant with two groups of 125 MW each (1961); in the Rio area, the supplementary plant of Lajes at Ponte Coberta, 90 MW, which will make use of the newly-stored tail-race water of the Fontes and Nilo Peçanha plants (1961). In addition the regulation of the upper course of the river Paraiba will make possible the installation of four or five more units of 65 MW each at the Nilo Peçanha plant, and the Santa Branca reservoir being built for this purpose is almost completed.

The Light Group is participating in the construction of the Furnas plant (Rio Grande in the State of Minas Gerais) as a member of the combine concerned, which includes the Federal Government and the Governments of Minas Gerais and São Paulo. This plant will supply power to the group through a 345 kV line 350 kilometres long (Furnas to São Paulo). This line will be the basis of the interconnexion of the system with the system being developed in the State of Minas Gerais. Thus the central-south area of Brazil will be making the fullest use of its water resources, by making large transfers of power between systems based on the diversity of the hydrologic regimes and the existence of large storage reservoirs.

Thus the Peixotos plant on the Rio Grande (Companhia Paulista de Força e Luz) will also be able to supply the system with power. At this plant 80 MW were installed in 1957, and 95 MW in 1960. It is hoped that 142 MW will be brought into service in 1962 and another 142 MW in 1963. On the Paraiba river projects at Salto-Paredao Funil (210 MW), Anta-Benjamín Constant (400 MW) and Simplicio (200 MW) are under study.

Studies are also being carried out with respect to projects at Registro (45 MW), El Dorado (120 MW), Descalvado (180 MW) and Ribeira (96 MW), in the Ribeira valley, but transport and geological difficulties in this valley preclude rapid progress with these projects.

/In addition

In addition to the capacity planned mainly on the basis of water resources, there are government and private plans for installing nuclear reactor. The most advances of these projects appears to be that at Mambucaba (100-150 MW), between Rio de Janeiro and São Paulo and 50 kilometres from the line of interconnexion between the two cities. The Superintendencia of the Mambucaba project (established in December 1959) is the body responsible for co-ordinating the legal, administrative, financial and economic aspects of the execution of this project.

(e) Price of power

In 1959 the average price of 1,000 kWh for industry in Rio de Janeiro equalled that of 0.27 tons of diesel oil or 0.78 tons of coal; in São Paulo the corresponding figures were 0.25 tons of diesel oil or 0.61 tons of coal.12/

2. System of the Companhia Paulista de Força e Luz

This system belongs to the Empresas Eletricas Brasileiras, subsidiaries of the American and Foreign Power Co. (Electric Bond and Share Co.), and represents some 40 per cent of the power generated by that group.

It distributes electricity in 180 municipalities in the interior of the State of São Paulo and in four in the State of Minas Gerais, and covers an area of nearly 80 square kilometres. Nearly all its networks are interconnected, and it thus constitutes an extensive system which in turn is linked with the Light system of São Paulo.

In 1959 the estimated population of the municipal centres in its territory was slightly over a million, and the total population almost 3 million; the number of registered consumers was over 310,000.

12/ Sources for this section: Plano Nacional de Eletrificaçao e Centrais Eletricas Brasileiras, S.A.; Estado de São Paulo, Plano Estadual de Eletrificaçao (Secretaría da Viaçao e Obras Públicas); O Problema da Energía Elétrica no Brasil CEPAL/DOAT (Gen. Carlos Berenhauses Jr.); Sao Paulo Light S.A., Serviços de Eletricidade, Annual Report (1958 and 1959); "Energía Eletrica e Desenvolvimento Industrial no Brasil" (Mario Savelli), Eletricidade; Report of the Preliminary Assistance Mission to Brazil (International Atomic Energy Agency - STI/DOC/16), and direct information.

The industrialization of the territory served by the Companhia Paulista de Força e Luz is not confined to the many enterprises processing coffee, cotton, rice, etc., and based on agricultural production, but also includes a number of manufacturing works (textiles, rubber products, chemicals, paper, etc.).

The total maximum demand for all the generating plants together amounted to about 238 MW in 1959, with a total production of 1,250 MWh. These figures represent 6.8 per cent and 6.7 per cent respectively of the installed capacity and total production of the public service electricity enterprises.

(a) Consumption trends

In 1959 net per capita consumption (excluding losses and plant consumption) amounted to 350 kWh in relation to the total population of the area and 1,020 kWh in relation to the urban population alone. An annual increase of 11.7 per cent in generation was required during the period 1950-59, compared with a demographic growth of about 2.8 per cent.

Consumption by type of consumer in 1959 was distributed as follows: domestic 21.7, commercial 11.8, industrial 28.8 and others (mainly rural consumption) 35.7. In 1948 the distribution was: domestic 29.6, commercial 11.2, industrial 35.7 and others 23.5. Special attention is drawn to the increase in rural consumption. The proportion of industrial and commercial consumption in the system is slightly lower than the national average. The system's consumption represented the following percentages of the total consumption for the public service for the country as a whole: domestic 14.0, commercial 5.3 and industrial 5.0.

The annual load factor was 0.60 in 1959 compared with 0.57 in 1956. Distribution losses, plant consumption and unmetered consumption amounted to over 20 per cent of production.

/(b) Plants

(b) Plants and lines

Generation is mainly hydraulic, as can be seen from the following list of plants:

Plant	Type	Capacity (MW)	Date when the machinery was installed
Peixoto	Hydraulic	175	1957-60
Americana	Hydraulic	30	1949-54
Avanhandava	Hydraulic	30	1946
Jaguari	Hydraulic	12.7	1919-57
Maribondo	Hydraulic	7.9	1928
Others	Hydraulic	26.6	...
Carioba	Thermal	30.0	1954

A total of 460 MW will be installed at the Peixoto plant, and it is estimated that 142.5 MW will be added every two years until this capacity has been attained. In addition the Estreito project (800 MW) is under study. The system networks with voltages higher than 11 kV represent more than 8,000 kilometres, of which 400 kilometres are of 132 kV lines and 1,500 kilometres of 66 kV lines. The frequency used is 60 cycles, and the triphase low-tension distribution is mainly with four conducters at 127/220 V.

(c) Price of power

The average price of 1,000 kWh for industry within the system in 1959 equalled that of 0.25 tons of diesel oil or 0.61 tons of coal.[13/]

13/ Sources for this section: Those indicated for the Light Group, plus the report of the Board of Directors of the Companhia Paulista de Força e Luz.

3. Centrai Eletricas de Minas Gerais (CEMIG)

The State of Minas Gerais, where the CEMIG company operates, has extensive mineral resources (iron, aluminium, etc.) with favourable conditions for exploitation. However, the area lacks fuels, and consequently the use of this mineral wealth requires the prior development of hydroelectric resources, which are also plentiful in this State. In order to accelerate the development of these hydroelectric resources, and in order to co-ordinate the power plans of the many enterprises that supply this area, the CEMIG enterprise was founded in 1952 as a limited company with mixed capital in which the funds of the State of Minas Gerais predominate. At the time when this company was established the electricity companies of Alto Rio Doce, Medio Rio Doce and Alto Rio Grande became part of CEMIG as subsidiary companies. The electricity companies of Piaú and Furnas, both limited companies, are also linked with CEMIG as associated companies.

CEMIG's present territory is the central-southern part of the state, where the main cities are concentrated, including Belo Horizonte, the State capital. The main industries are also in this area, with a production that amounts to nearly the total for the whole State. As an industrial centre Minas Gerais holds fifth place among the states of Brazil.

CEMIG supplies electricity directly to over 40 localities, of which the most important is the industrial sector of Belo Horizonte (Cidade Industrial). It also supplies block power to other enterprises for them to distribute; the two most important of these are the Companhia Força e Luz de Minas Gerais and the Companhia Sulmineira de Eletricidade, with which it was connected in 1959. The first of these two uses the power supplied by CEMIG to meet part of the demand of Belo Horizonte. Of the total of 313.3 million kWh that this company had available for its distribution in 1959, 207.4 million represented power bought from other producers, of which CEMIG was the largest supplier.

The area supplied directly and indirectly by CEMIG has risen from 10,600 square kilometres in 1952 to 42,000 in 1957 and 85,000 in 1959, and it is expected to increase to about 194,000 in 1962. The total area of the state is 582,000 square kilometres.

/The population

The population supplied has increased from 650,000 in 1952 to 1.1 millon in 1955 and 2.5 million in 1958,and it is expected to be 5.0 million by 1965. The estimated total population of the state in 1959 was close to 9.0 million.

Installed capacity in all the plants belonging to CEMIG has developed as follows:

Year:	1952	1953	1954	1955	1956	1957	1958	1959
kW:	12,500	14,000	16,900	64,400	114,600	121,700	172,000	191,600

Installed capacity in 1959 was represented by the following plants:

Plant	Type	Capacity (kW)	Head (metres)
Cafanhoto	Hydraulic	32,500	30
Cajurú	Hydraulic	7,200	23
Itutinga	Hydraulic	37,500	29
Salto Grande	Hydraulic	100,000	103
Piaú	Hydraulic	18,000	210
Tronqueiras	Hydraulic	4,000	120
Ilheus	Hydraulic	3,000	37
Santa Marta	Hydraulic	4,000	
Carandaí	Hydraulic	1,000	
Cidade Industrial	Diesel	4,400	

Of these plants, Tronqueiras, Piaú and Santa Marta operate as independent systems; the others constitute the interconnected CEMIG system.

The following are some of the features of the reservoirs of the system:

(i) The Cajurú reservoir regulates the supply of water to Cafanhoto downstream and to Cajurú at the foot of the servoir. Its useful volume is 163 cubic metres (22 million kWh).

(ii) The Itutinga reservoir, at the plant of that name, has 6.5 million cubic metres of useful volume, the equivalent of about 400,000 kWh.

(iii) The Guanhaes reservoir regulates Salto Grande and holds the equivalent of 58 million kWh.

/The main .

The main projects for the near future are the Tres Marías and Furnas plants, in both of which CEMIG is associated with other bodies or enterprises. The first of these will be supplied by the Tres Marías reservoir, which will hold 22,000 million cubic metres in a flooded area of some 1,300 square kilometres. The plant's final installed capacity will be 520 MW.

The Furnas plant will be supplied by the Furnas reservoir, which will have a useful volume of 14,000 million cubic metres in a flooded area of 1,400 square kilometres. At its final stage this plant will have a capacity of 1,200 MW. At all stages half the power generated will go to CEMIG.

Another project under construction, and at a very advanced stage, is the Camargos plant, with a reservoir of 750 million cubic metres of useful volume representing 100 million kWh and generating plant amounting to 45,000 kW. This reservoir will make it possible to double Itutinga's installed capacity.

There is no thermal project of any importance.

In the six-year period 1954-59 the total generation of the CEMIG group plants was as follows:

Year:	1954	1955	1956	1957	1958	1959
Million kWh:	46	150	336	541	747	851

The power generated in 1959 represented approximately 35 per cent of the total for the State; it is expected that by 1962 this figure will increase to 60 per cent.

Of the power generated in 1959, 83.8 million kWh represented transmission and distribution losses, and 2.3 million plant consumption. Thus undistributed power amounted to about 10 per cent power generated.

The interconnected CEMIG system operates on a frequency of 60 cycles; as previously indicated, this generating frequency is used by some of the major enterprises in Brazil.

Since 1955 consumption, maximum annual demand and annual load factor in the system have been as follows:

/Year

Year	Consumption (million kWh)	Maximum demand (MW)	Load factor
1955	131,8	44.300	0.387
1956	303,1	72.000	0.529
1957	493,1	97.000	0.639
1958	673,6	150.000	0.571
1959	768,1	155.000	0.630

In 1959 rationing had to be imposed, especially in the industrial sector, as a result of the drought in the area.

The CEMIG group consumption is mainly industrial, as can be seen by the following figures, expressed in million kWh:

Type of consumption	1955	1956	1957	1958	1959
Domestic	2,3	4,4	11,0	15,2	19,1
Commercial	1,7	3,1	5,9	8,2	10,1
Industrial	80,7	179,9	340,1	503,8	575,2
Other enterprises	39,4	101,9	106,6	112,3	125,2
Other	7,7	13,8	29,5	34,1	38,5

Industrial consumption has increased relatively and in 1959 amounted to 75 per cent of the total. Per capita consumption in CEMIG's territory amounted to some 400 kWh in 1959.

The existing plants, together with the Tres Marías and Furnas plants under construction, will easily be able to meet the estimated demand of 3,000 million kWh by 1965 and 6,500 million by 1970.

In 1959 CEMIG had an extensive network of transmission lines. The number of kilometres corresponding to the various voltages used was as follows:

kV:	161	138	69	44	345	22	13,8
km:	142	239	670	105	74	57	24

The distribution network consisted of 369 kilometres of high tension lines and 699 kilometres of low tension lines, and a total of 365 kilometres of rural lines.

/The main

The main transmission lines now under construction are those carrying power to the system from Furnas and Tres Marías. The Furnas-Belo Horizonte stretch will be 200 kilometres of 345 kV lines, and that from Tres Marías to Belo Horizonte will be 250 kilometres of 275 kV line.[14]

4. System of the Companhia Hidroeletrica de Sao Francisco (CHESF)

This sytem began operating in 1955.

The concession area includes 347 municipalities in 8 Brazilian states, mainly in the area known as Polígono das Secas, in the north-east of Brazil, with an area of approximately 516,000 square kilometres and over 11 million inhabitants, mainly rural, as the estimated population of the municipal centres in 1959 was some 2.8 million.

Present installed capacity amounts to 200 MW, of which 180 MW represents the first-stage equipment of the Paulo Alfonso hydroelectric plant and 20 MW the Cotegipe thermal plant.

The following data on the service provided by the Paulo Alfonso plant illustrates the system's rate of expansion:

Year:	Maximum demand at the plant (MW)	Total power generated (Millions of kWh)
1955	69	226
1957	118	440
1959	160	(710)

In 1959 per capita consumption levels were 65 kWh in relation to the total population and 255 kWh in relation to the population in the municipal centres only.

In 1958 maximum demand and power generated in the system represented 6.9 per cent and 3.9 per cent respectively of total maximum demand and production of the main public services for the whole country.[15]

14/ Sources for this section: Reports of the Centrais Eletricas de Minas Gerais S.A.; Evoluçao das Centrais Eletricas de Minas Gerais e sua influência na indústria metalúrgica, Candido Hollanda de Lima, 1959; reports of the Companhia Força e Luz de Minas Gerais; Aumento de capital da Centrais Elétricas de M. Gerais S.A. Memorandum and Bill presented by Gov. José Fco. Bias Fortes; and direct information.

15/ Information provided by the Paulo Alfonso plant indicates that the load factor improved (from 0.37 in 1955 to 0.51 in 1955) as industrial demand was established as a result of the removal of restrictions in areas that formerly had an inadequate electricity service and the incorporation of areas that formerly had no service.

/(Transmission lines

Transmission lines in use amount to over 2,500 kilometres, of which 220 kV lines alone represent over 860 kilometres.

The frequency used is 60 cycles.

The electrification plan for the north-east, drawn up in April 1959, deals with the following main aspects:

	In service	Under construction	Projected	Total
Generating capacity (MW)	200	130[16]	385	715
Transmission lines (No. of km of 220, 132, 66 and 13.8 kV lines)	2,500	800	7,500	10,800
Distribution substations (MVA)	230	400	580	1,210

New distribution networks are to be established in 162 towns. The increased demand for the next few years allowed for in the expansion provided in the plan is as follows:

	1963	1966
Power (thousands of MWh)	2,596	3,547
Maximum demand at plants (MW)	605	779

The plan represents some 225 million dollars, of which about 70 per cent would be in local currency.

The average price of power sold in 1955 was 0.425 cruzeiros per kWh, compared with 0.703 in 1959; this represented an increase of 65 per cent as against an increase of 80 per cent in the cost of living index for the same period. Distribution features vary for the various towns in the system, the predominant method being triphase four-conductor distribution at 220/380 voltages, although 127/220 voltages are also used.[17]

16/ Excavations have already been made for the second power house, which like the first is underground, and will contain six units of 65 MW each. The construction of a third power house containing 100 MW units is under consideration.

17/ Sources for this section: Various reports of the Companhia Hidroeletrica da Rio Sao Francisco. (CHESF).

IV. COLOMBIA

1. Bogotá System

The most important system in Colombia, apart from that of Medellín, is the one feeding the Bogotá district and some of the small towns near-by (Facatativá, Bojoca, Madrid, Mosquera, Funza, Fontibón, Suba, Usaquén, La Caro, La Calera, Chía, Tibito, etc.). It is owned by a municipal body called the Empresa de Energía Eléctrica de Bogotá. The peak demand served by the generating plants in 1959 was 127 MW, certain restrictions relating to the type and dimensions of new plants, and to the collection of special charges known as the "network development levy". The power generated amounted to approximately 600 million kW. These values represented about 20 and 22.2 per cent, respectively, of the installed capacity and total generation of Colombia's leading public service companies. In 1959, the area served by the system comprised a population of approximately 1.08 million inhabitants (7.7 per cent of the total population), with a little over 116,000 subscribers. Net per capita consumption stood at about 500 kW.[18/] The cumulative annual rate of increase of generation averaged 12.1 per cent in 1950-59 (which implies doubling in about 6 years), whereas that of the population was 5.4 per cent.

(a) Consumption

The percentage distribution of consumption by types of consumer in 1958 was as follows: household, 28.9; commercial, 27.1; industrial, 30.5; street lighting, 4.3; transport and other uses, 1.7; and official consumption, 7.5.

In 1950-58, the following were the average growth rates by sectors of consumption: household, 13.9 per cent; commercial, 14.5 per cent; industrial, 10.8 per cent; street lighting, 7.0 per cent; and other uses, 15.2 per cent, electric traction having decreased at an annual rate of 9.6 per cent. In the year 1956, the system under discussion covered the following percentages of the main public utility consumption figures for the country as a

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18/ The average for the whole country was about 160 kW per capita (public service only).

/whole, by

whole, by types of consumer: household, 12.2; commercial, 39.5; industrial, 24.1;[19] street lighting, 10.3; and transport and other uses, 28.2. Transmission and distribution losses were estimated at 13.6 per cent of total generation in 1958.

(b) Power stations and lines

A total installed capacity of 128 MW was provided by the following power stations: the hydroelectric plants known as Charquito (5.5 MW), Salto I (50 MW) and Laguneta (3 units, 54 MW), and the Charquito thermal plant (14.5 MW).[20] All these power stations are situated on the River Bogotá, near the edge of the savannah and between 30 and 40 kilometres from the capital. In 1959, hydro power accounted for 97 per cent of the total amount generated, the rest being thermal.

As regards industrial self-suppliers, the Samper Cement Company (Empresa Cementos Samper) owns a run-of-river plant with an installed capacity of 8 MW, but its firm capacity often drops to 1 MW. During such periods, this factory purchases energy from the Bogotá system to satisfy its demand up to 5 MW, but when the water situation is favourable, the position is reversed. In 1958 its sales to Energía Eléctrica de Bogotá exceeded its purchases from the system by more than 8 million kWh. The annual plant load factor was 0.54 in 1959, having been 0.55 in 1949 and 0.61 in 1955. This last value - the highest on record - related to the period of particularly severe restrictions and rationing which preceded the entry into service of the Laguneta power station. On a given working-day in May 1958 the load factor reached 0.66.

The maximum power dispatched and the capacity of the generating plants were approximately equal in 1959. The frequency used is 60 cycles.

The system's transmission and distribution lines comprise 207 kilometres at 57.5 kV;[21] 15 kilometres at 30 kV, 51 kilometres at 20 kV and 59 kilometres

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19/ Including the public-utility power sold to certain mining concerns.

20/ Dates of installation were: Charquito, 1920; Salto I, 1947; Laguneta, 1957; Charquito (thermal), 1937 (6.5 MW) and 1955 (8 MW).

21/ Between the plants and the city of Bogotá there are three double-circuit lines, the respective lengths of which are 23.25 and 30 kilometres.

/at 11.4

at 11.4 kV, 581 kilometres at 6.6 kV and 960 kilometres at 2.6 kV, all overhead. There are also about 195 kilometres of underground cables at 6.6 kV. The line between Laguneta and Bogotá is designed to operate at 115 kV, i.e. the voltage at which part of the existing system, and the future transmission lines, will be working when the projected power stations enter operation.

(c) Plans for the future

Plans are afoot for the conversion of most of the 6.6-kV lines to 11.4 kV. The low-tension network operates at 150-260 V (4 conductors); its conversion to 120-208 V is under study.

The immediate programme of which the first phase is under way is based on the harnessing of the River Bogotá by means of the regulation of its flow. This river would seem to be one of the most economic sources of electricity in Colombia. The installation of a fourth unit (18 MW) at Laguneta is planned for 1960, and that of the 66-MW Salto II plant for 1962. A further 33 thermal MW will be installed at Zipaquirá, and the distribution networks are to be expanded. Somewhat longer-term projects, to be executed in successive stages, relate to continuing the development of the River Bogotá with the construction of the following plants: Charquito II (16 MW) in 1963, 5.5 MW being withdrawn from Charquito I; Neusa (25 MW) and Canoas (24 MW) in 1964; half of Power Station No. 5 (62 MW) in 1965 and the other half in 1966; and, lastly, Power Station No. 6 (105.5 MW) in 1968. According to the projections, installed capacity should thus exceed peak demand by 16 and 22 per cent in the years 1965 and 1968, respectively.

For the initial phase, a loan has already been obtained from the International Bank for Reconstruction and Development, and in the course of the next 6 years the company is planning to invest 28 million dollars (63 per cent in foreign and the rest in local currency).

The remainder of the entire programme implies the investment of 113 million dollars by 1968 (40 per cent in national and 60 per cent in foreign currency), which would cover the expansion of the distribution networks in consonance with the increase in load capacity.

/(d) Price

(d) Price equivalences

The average price of 1,000 kWh was equivalent to the sales price of 0.2 tons of diesel oil and to that of 0.36 tons of fuel oil.[22/]

2. Medellín System

This system is owned by the Empresas Públicas de Medellín, an autonomous body which is organized on the basis of municipal capital, and which also incorporates the drinking-water, sewage and telephone services. It feeds the city of Medellín and some of the neighbouring townships in the Central Section of Antioquia (Bello, Copacabana, Envigado, Itagüi, Guarme, Caldas, as well as Entrerríos, Don Matías, Guadalupe, Carolina, Gómez Plata, etc.). The peak load at the generating plants was 147.5 MW in 1959, and 724 million kWh were generated; account must be taken of the fact that for several years now rationing has been applied, particularly during dry spells. The figures just given represented about 23.2 and 26.8 per cent, respectively, of the installed capacity and total output of Colombia's principal public utility companies.

(a) Consumption

In 1959, the area served by this system contained a population estimated at 570,000 inhabitants (4.1 per cent of the total population of Colombia). Net per capita consumption amounted to 1,150 kWh in that same year, i.e., about six times the average for the country as a whole, if the public service only is taken into consideration. During the period 1950-59, generation increased at an annual geometric rate of 10 per cent,[23/] while the corresponding figure for population growth was 6.4 per cent. The number of subscribers in 1959 slightly exceeded 95,000, giving an average of one subscriber to every six inhabitants. In the same year, the percentage break-down of consumption, by types of consumer, was as follows: household, 55.8;

22/ In addition to direct information, data for this section were obtained from the following: Empresa de Energía Eléctrica de Bogotá, Development Program - 1959; Republic of Colombia, National Electrification Plan; United States Department of Commerce, Electric Power in Colombia; ECLA, The Economic Development of Colombia, United Nations publication, Sales No.: 1957.II.G.3.; and National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadística), Anuario Estadístico 1958, Special District of Bogotá.

23/ This implies doubling in a little over 7 years.

commercial, 7.2; industrial, 24.4; street lighting, 6.0; and other uses, 6.6. Losses were estimated at approximately 11 per cent of total generation.

(b) Power stations and lines

The Empresas Públicas de Medellín generate nothing but hydroelectric energy at the following power stations: Guadalupe I (40 MW - four units of 10 MW each), 120 kilometres north-east of Medellín by road, on the River Guadalupe; Guadalupe II (10 MW - one unit only), near the foregoing; Rio Grande (75 MW - three units of 25 MW each), situated 65 kilometres away from Medellín by road, on the Rio Grande; and Piedras Blancas (11.5 MW). One unit set up on the water supply pipeline to the town (in 1958) is brought into operation mainly at peak-load hours. The Compañía Colombiana de Tejidos (COLTEJER) has a 19.5-MW thermal plant which is connected with the system and serves it as a stand-by during certain months of the year; in 1959 this source accounted for only 2.2 per cent of the power generated.

The annual plant load factor was 0.56 in 1959, whereas in 1949 it had been as high as 0.61.[24/] On the day in 1959 when demand reached its maximum (in the month of November), the load factor exceeded 0.657.

The relation between the maximum load dispatched and the plant capacity available was something like 94 per cent, taking 10 MW to be obtainable for the system from COLTEJER. This shows how inadequate the service is in relation to consumer demand, especially in view of the severe rationing applied and the fact that the annual growth rate of consumption is approximately 10 per cent.

The frequency used is 60 cycles per second. A double transmission line (120 kV) 80 kilometres long connects the Guadalupe plants with the Poblado substation, and another with the same characteristics, 50 kilometres in length, connects this substation and the Rio Grande plant.

The Piedras Blancas power station is interconnected, by means of a 15-kilometre line, with the other 120-kV lines north of Medellín. Intermediate distribution is effected at 13.8 kV (4 conductors). The low-utilization voltages most commonly adopted in the system are 120-208 V (4 conductors).

24/ Rationing probably distorted load characteristics more noticeably in 1949 than nowadays, the service having been restricted chiefly at peak hours.

(c) Plans for the future

The initial phase of the expansion programme in force comprises the installation of the first two units of the Guadalupe III plant (40 MW each), for entry into service in 1960 and 1961, and of the first 18 MW of the Troneras Power Station (1962). On 20 May 1959, the International Bank for Reconstruction and Development granted a loan of 12 million dollars, amortizable in 22 years, for the execution of these works. Projects are also afoot for the construction of the Guatape plant on the River Mare, by stages as follows: 1st. unit (37 MW) in 1964; 2nd. and 3rd. units (74 MW) in 1965; and a 4th. unit (37 MW) in 1966. Its remaining four units, also totalling 148 MW, will probably be installed in 1968-70. Furthermore, at the Guadalupe plant 80 MW (3rd. and 4th. units) are expected to enter operation in 1967. On the basis of the plan outlined, installed capacity should reach 346 MW by the end of 1965 and 611 MW by 1970, thus exceeding the maximum demand projections for the years in question by only 5 per cent. The investment contemplated for the first phase (80 MW at Guadalupe III and 18 MW at Troneras), including the transmission and distribution systems concerned, amounts to 20 million dollars (50 per cent in foreign exchange and 50 per cent in local currency). It would seem that investment requirements for the total programme up to 1970 will reach 85 million dollars.[25/]

(d) Price equivalences

As regards the substitution of other sources of energy in the industrial sector, the average price of 1,000 kWh was equivalent to that of 0.175 tons of diesel oil and 0.3 tons of fuel oil.[26/]

25/ The investment figures indicated both for the first phase and for the whole of the plan are exceptionally low (200 and 180 dollars per kilowatt installed, including transmission lines and distribution networks), and will probably be readjusted when the projects are revised.

26/ Apart from the direct information received, the following documents were consulted for this section: Republic of Colombia, National Electrification Plan; United States Department of Commerce, Electric Power in Colombia; The economic development of Colombia, op.cit.; the National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadística), Anuario Estadístico 1958; and Empresas Públicas de Medellín, Balance e Informes 1959.

V. COSTA RICA

1. Compañía Nacional de Fuerza y Luz

The Compañía Nacional de Fuerza y Luz (CNFL) is a private concern and a subsidiary of American and Foreign Power, which has been operating in Costa Rica since 1928. Its concession area is constituted by San José (the capital) and 36 population centres in the vicinity, covering approximately 300 square kilometres. It is the part of the country with the highest population density, in the neighbourhood of 1,000 inhabitants to the square kilometre, and in it is concentrated about one third of the population of Costa Rica, which in 1960 was estimated at 1.1 million inhabitants.

Industrial activity is also concentrated in this same zone, but has not yet reached a significant level of development. It is limited to such industries as textile manufactures, food processing, steel making, etc.

From the standpoint of installed capacity, this company comes next in importance after the State undertaking known as the Instituto Costarricense de Electricidad (ICE). Out of the entire electricity supply available for public utility purposes in Costa Rica in 1959 (100,000 kW), the CNFL accounted for 38,600 kW, or 39 per cent. Its installed capacity consists of hydroelectric units totalling 28,600 kW and steam units representing 10,000 kW, as is shown in detail below.

Name	Installed capacity kW	Type	Number of units	Date of installation
San Antonio	10,000	Steam	2	1954
Ventanas	10,000	Hydro	4	1944
Nuestro Amo	7,500	Hydro	2	1949
Brasil	5,315	Hydro	4	1912-31
Belén	2,800	Hydro	5	1912-26
Electriona	2,120	Hydro	2	1928
Anonos	600	Hydro	...	...
Río Segundo	150	Hydro	1	1924

/None of

None of the hydroelectric plants is equipped with means of seasonal regulation. The installed capacity of the CNFL is insufficient to meet the requirements of the zone it serves. This deficit became critical in 1954 as a result of the drought which scourged the centre of the country. The situation was partially remedied in 1956 by the entry into service of the ICE-owned Colima diesel plant, which sells the whole of its output to the CNFL, and, more definitively, when the hydroelectric power station of La Garita, also the property of the ICE, entered operation in 1958.

A large proportion of the power distributed by the CNFL is purchased en bloc. Thus, in 1959, out of a total of 269 million kWh which the CNFL had at its disposal for distribution, 242 million were bought from the ICE and only 127 million were generated in its own plants. Of the energy thus generated, 4.5 million kWh were produced by the San Antonio thermal plant and 122.5 by the hydroelectric power stations. The 269 million kWh distributed by the CNFL represented 75 per cent of the country's total electricity output for the public service.

To dispatch this energy to the towns served, the Company possessed the following transmission and distribution lines:

77.7 km at 33 kV
109.7 km at 13.2 kV
322.7 km at 4.2 kV
224.9 km at 2.4 kV
232.0 km at 120 V

These figures give a total of 767 kilometres, in addition to 19 kilometres of 33-kV lines which were under construction in 1959. The lines listed interconnected the different plants with one another and the whole system with the Colima diesel plant, which is the distribution centre for the ICE's sales of the energy produced at the Colima and La Garita power stations.

Total transmission and distribution losses amounted to only 13.4 per cent in 1959, as compared with the 23.1 per cent they had represented in 1950.

The population of the area served by the CNFL increased from 201,000 inhabitants in 1950 to 291,000 in 1959, which implies an annual growth rate

/of 4.2

of 4.2 per cent. Consumption in its turn rose in the same period from 100 million to 231 million kWh, at an annual rate of 9.7 per cent. Population and consumption figures for 1959 represent a per capita consumption of 800 kWh, which is in marked contrast with that of 115 kWh (public utility only) registered for the rest of the country.

Owing to the slow rate of development of industrial activity, commercial and residential consumption are the preponderant types. The high figure for household consumption is to a large extent attributable to the low sales price per kWh, which in 1959 averaged 2.02 cents, and in the case of electricity for household use was only 1.79 cents.

The distribution of consumption by types of service was as follows:

	Millions of kWh	Percentage
Household	170	73.5
Commercial	32	13.9
Industrial	14	6.1
Other services	11	4.8
Block sales	4	1.7

The modest price of electric energy is due, on the one hand, to low production costs (very advantageous sites, short transmission lines, etc.), and, on the other, to a buoyant consumer market and the reduction of profit to the minimum acceptable. Nevertheless, in the last ten years the rise in the price per kWh delivered to the consumer has outstripped that of the cost of living, as the following table shows (1950 = 100):

	Cost of living	Price per kWh
1950	100	100
1955	111	120
1959	119	137

2. The Instituto Costarricense de Electricidad

The Instituto Costarricense de Electricidad (ICE) was established by a decree dated 8 April 1949 as an autonomous State institution for the public service. This agency has been made responsible for studying the country's electricity requirements, promoting the rational utilization of its hydroelectric resources and supplying power on a non-profit-making basis, purely with a view to the development of productive activities.

/At the

At the present time, the ICE supplies mainly the central zone of Costa Rica, but by means of block sales of almost all its power to other undertakings concerned with distribution, such as the Compañía Nacional de Fuerza y Luz (CNFL) in San José and neighbouring towns, or the Municipal Services of Heredia and Alajuela. It also serves a few isolated population centres in other parts of the country (Puerto Limón, Liberia, Santa Cruz, etc.).

Since it was set up, the Institute has installed the following plants: (a) The Colima diesel plant (11,880 kW), not planned for in the initial programme and constructed with the sole aim of remedying the critical supply situation which affected the central zone in 1954. This plant entered operation in 1955; (b) The hydroelectric power station of La Garita (30,000 kW), whose two units of 15,000 kW each were brought into service in mid-1958.

In accordance with the National Electrification Plan, the Río Macho No. 1 hydroelectric plant is at present under construction; the work is to proceed by stages, 30,000 kW being installed during each phase, until the completion of the projected 150,000 kW. Besides these two important power stations, in 1959 the ICE possessed the following low-capacity plants:

Name	Type	Installed capacity (kW)
Nagatac	Hydro	1,500
Barro Morado	Hydro	870
Guacimal	Hydro	720
Asunción	Hydro	718
La Isabel	Hydro	360
Hopkins	Hydro	300
Colorado	Hydro	1,300
Puntarenas	Diesel	976
Limón	Diesel	976
Colorado	Diesel	510
La Parina	Diesel	440
Santa Cruz	Diesel	142

/These plants

These plants taken together make up a total of 49,530 kW, 34,610 kW being produced by hydroelectric plants and 14,920 kW by thermal plants. From the point of view of its installed capacity, the ICE has become the country's main electricity concern, its facilities representing 49.5 per cent of total public service installed capacity.

Since the power station of La Garita was put into service, ICE production has become predominantly hydroelectric. In 1959, the amount of hydroelectric power generated amounted to 168 million kWh as against 20 million kWh generated thermally or a proportion of 89 per cent and 11 per cent. In addition to its own generation, the ICE also purchased 16 million kWh in 1959 from the Compañía Agrícola de Santiago, thereby making the total amount of power it had available up to 204 million kWh. Of this amount 154 million kWh or 76 per cent of the total is block sold, the majority of it being intended for the CNFL for supply to the San José area.

Of the total amount of electricity generated in the country in 1959, which amounted to 361 million kWh, ICE production accounted for 52 per cent.

For the transmission of power, the ICE has a 138 kW line, 31 kilometres long, interconnecting the power station of La Garita with the Colima plant and through it with the CNFL. In addition, an approximate total of 160 kilometres of 34.5 kV lines and other lesser lines dispatch the power generated at Colima and La Garita to the whole area between Turrialba and Puntarenas.

Transmission losses and unregistered consumption in towns supplied by the ICE through the National Electricity System amounted to 6.4 million kWh out of the total of 50 million kWh dispatched to the System, or an approximate percentage of 13 per cent. The very small losses involved in the sale of power to the CNFL, appreciably reduce the foregoing percentage.

The number of people directly supplied by the ICE was estimated in 1959 at nearly 150,000. These people, as has already been stated, consumed 44 million kWh, giving an average figure of 290 kWh per capita.

The breakdown of consumption by areas and type of consumer in the centres supplied direct is as follows:

/Areas:

Areas:	Millions of kWh	Percentages
Pacific area	19.0	43.1
Central area	1.0	2.3
Puerto Limón	16.0	36.4
Liberia	7.0	15.9
Santa Cruz	1.0	2.3
	44.0	100.0
Type of consumption		
Household	27.1	62.0
Commercial	6.9	15.5
Industrial	4.9	11.0
Other	5.1	11.5
	44.0	100.0

VI. CHILE

1. Interconnected system

The largest electricity system in Chile is the one covering the third and fourth geographical zones of the country. Originally it comprised only the system of the Compañía Chilena de Electricidad,[27] situated approximately between the rivers Aconcagua and Maipo. As the Empresa Nacional de Electricidad S.A. (ENDESA)[28] proceeded with the construction of power stations and transmission lines, new sectors were incorporated[29] until in 1958 an area from La Ligua to Temuco, or approximately 6.5 degrees of latitude, had been covered.[30] In 1959, the provinces in the third zone served by the system included: Aconcagua, Valparaíso, Santiago, O'Higgins, Colchagua, Curicó and Talca, in addition to the department of Constitución (province of Maule) and the departments of Loncomilla and Linares (province of Linares); and in the fourth zone the departments of Chanco and Cauquenes (province of Maule), the department of Parral (province of Linares) and the provinces of Ñuble, Concepción, Bío-Bío, Arauco and Malleco.

27/ With capital supplied by the Electric Bond and Share Company (EBASCO) of the United States.

28/ Autonomous concern with capital provided by the State. It is responsible for carrying out the Chilean national electrification plan. It was set up in 1943 to pursue and broaden the work started by the Corporación de Fomento de la Producción (CORFO).

29/ In 1949 the area from Rancagua to Talca was brought into service; in 1955 the areas from Chillán to Los Angeles, from Melón to La Ligua and from Los Angeles to Victoria and finally in 1957 the town of Temuco itself were brought into service.

30/ In June 1960 construction work was completed on the San Pedro-Illapel line (110 kV and 170 kilometres long), thereby connecting the Molles System (second geographical zone) with the Interconnected System. In this way, Juan Soldado is connected electrically with Temuco, a distance of nearly 1,000 kilometres. The Interconnected System at present extends from Copiapó to Puerto Montt (1,500 kilometres) (May 1961).

/The two

The two zones have a total area of almost 132,000 sq. kilometres, 29 per cent of which is agricultural. The total population in 1959 amounted to 5.3 million or 71.5 per cent of the country's total population, while the urban population in the two zones amounted to 3.3 million. The two zones account for 85 per cent of the country's industrial production and nearly 40 per cent of its copper output.[31/] The maximum demand met from the generating stations was 409 MW in 1959 and generation amounted to 2,175 million kWh.[32/] These figures represent approximately 73 per cent and 96 per cent respectively of the installed capacity and total production of the country's public service undertakings in 1959. In 1959, net per capita consumption (without counting transmission and distribution losses) was 360 kWh if both the urban and rural populations are considered and 570 kWh if the urban population alone is considered.[33/]

In the 1950-59 period, generation increased at an average annual cumulative rate of about 7 per cent,[34/] while urban population growth was about 3.4 per cent. The installed capacity supplying the system in 1959 was 559 MW, 79 per cent of which was provided by hydro stations and the rest by thermal plants.

The annual load plant factor in 1959 was approximately 0.60. In 1949, the same factor, if the system had existed at that time, would have been somewhat less than 0.53.[35/] On working days in the winter the load factor

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31/ The Teniente Mine to the south of Santiago at Sewell has its own electricity generating plants (Coya and Pangal), with 55 MW which operate independently on 60 cycles per second.

32/ As in other years, certain restrictions were placed on consumption supplied by the Compañía Chilena de Electricidad between 1 May and 30 September.

33/ The average of public service generation for the whole country for the same year was 307 kWh per capita.

34/ For the years when the power stations were not interconnected, data regarding generation, installed capacity, etc. were added together for the centres later covered by the system under consideration.

35/ The distributing concerns operating within the system (with the exception of the Cía. Chilena de Electricidad) have not restricted consumption in recent years. As a result industrialization within them reflects an increase in the load factor.

/reached a

reached a figure of 0.70. The seasonal variation of average demand was 13 per cent as between summer and winter, as related to average demand for the year.

The ratio between the maximum output dispatched and the installed capacity of generating plants (the utilization factor) was 0.73. Considering that for the years of service there were some 30 MW thermally generated in unsatisfactory conditions and that in winter the firm capacity of run-of-river plants is somewhat less than installed capacity, the utilization factor had in fact to be higher than 0.80 in relation to firm capacity.

In 1959, generation could be broken down as follows: hydroelectric 96 per cent (ENDESA 66.4 per cent, Cía. Chilena de Electricidad 23.9 per cent, other public service undertakings and self-suppliers 5.7 per cent) and thermal 4 per cent (Cía. Chilena de Electricidad 1.9 per cent, other public service undertakings and self-suppliers 2.1 per cent).

With hydro power accounting for such a large proportion of the total, the amount of power that could be stored in reservoirs (Cipresas and Abanico power stations) amounted in 1959 to approximately 410 million kWh, representing some 20 per cent of hydro production and slightly less than 19 per cent of the total for the system.

Installed capacity in the system could accordingly be split up in 1959 into the following percentages: ENDESA 58.0 per cent, Cía. Chilena de Electricidad 31.0 per cent, Cía. General de Electricidad Industrial[36/] 2.8 per cent, Cía. Nacional de Fuerza Eléctrica[37/] 0.2 per cent, and self-suppliers[38/] 8.0 per cent.

36/ Provides electricity service between Buin and Chimbarongo and between Dichato and Hualqui, including Concepción, Talcahuano, Tomé, Chiguayante, etc., in addition to the towns of Talca, Chillán, Los Angeles and Temuco.

37/ Provides electricity service in the towns of Curicó, Linares, San Javier and a number of neighbouring towns.

38/ Includes the coal companies, the Cía. Refinería de Azúcar de Viña, the Compañía de Acero del Pacífico and supply to Cemento Melón, Papeles y Cartones, and Carburo, estimated at 15 MW.

/The following

The following are the main generating stations:

(a) Cía. Chilena de Electricidad:

(i) Hydroelectric: Florida 13.5 MW, built in 1909; Maitenes 26 MW, built in 1923; Queltehues 36.5 MW, built in 1927 with a reservoir with storage capacity of 70 MWh, and Volcán 13 MW, built in 1942.

(ii) Thermal: Laguna Verde 55.7 MW with one unit installed in 1939 and the other in 1949, and Mapocho with 22 MW, now obsolete.

(b) ENDESA: All its generating plants in this system are hydroelectric: Sauzal 75 MW, with pondage capacity for 120 MWh, built in 1948; Sauzalito 9.5 MW, which was put into service in 1959; Cipreses 102 MW whose useful storage capacity will be 115 million kWh; Abanico 135 MW with storage reservoir in the Laja lake which in 1959 had a utilizable capacity of approximately 300 million kWh.

(c) Compañía General de Electricidad: Concepción 10.3 MW, thermal. Half this capacity should be considered obsolete.

(d) Self-suppliers and others: There are, in addition, generating plants belonging to self-suppliers with 15 MW hydroelectric and 30 MW thermal, which are interconnected with the main system and supply part of the electric power they produce to the public service; there are also many other small capacity plants.

The main transmission lines belonging to ENDESA which form part of the main system may be grouped in the following way: firstly, 154 kV - 320 kilometres (double circuit) with nominal capacity of 600 A (the limits stated correspond to the transformers in service; technical limits are very much higher); and 43 kilometres of 500 A; 150 kilometres (double circuit) of 300 A; 11 kilometres (double circuit) of 100 A; secondly, 110 kV - 67 kilometres (double circuit) of 300 A; and thirdly, 66 kV - 28 kilometres (double circuit) of 400 A; 109 kilometres of 250 A; 13 kilometres (double circuit) of 200 A; 157 kilometres of 150 A; 435 kilometres of 100 A and 252 kilometres of 50 A or less.

The Compañía Chilena de Electricidad has nearly 395 kilometres at 110 kV, 59 kilometres at 66 kV, 189 kilometres at 44 kV and 1,500 kilometres at 12 kV in addition to 355 kilometres of underground cables at 12 kV. In medium and low tension, the voltages used are 13.2 kV and 220/380 (four conductors) throughout the distribution networks. Frequency is 50 cycles per second.

The river basins feeding the Cipreses and Abanico power stations and the availability there of large-scale storage facilities (Cipreses is in the third zone and Abanico in the fourth) make it possible to carry out operations that are complimentary to each other and fit well with the working conditions of the run-of-river plants in the third zone. The flows of the rivers are larger in the periods of thaw in the area between Copiapó and Chillán and during the autumn and winter in the south. In addition, from the Río Maule southwards the lakes could be used as large-scale storage capacity and furthermore the coal mines are situated exactly in the centre of the Copiapó-Puerto Montt sector.

The hydroelectric development plans prepared by CORFO and ENDESA make use of the optimum conditions referred to for seasonal and daily fluctuations in the amount of power required and provide for the independent and interconnected development of the various geographical zones. This is without doubt the most economic way of utilizing water resources since in each river and basin, plans are being drawn up of the works to be carried out and their management is being prepared with reference simultaneously to present and future needs for electric power in a broad area of the country; this work is in addition to attention to irrigation, drinking water and industrial requirements connected with the river or basin concerned; at the same time projections are made for overall development of the river basin. In this way, in 1958, 10 million kWh were transferred from north to south and nearly 95 million kWh from south to north. The stand-by facilities for the Santiago area provided by the Abanico and Cipreses power stations were particularly effective when the Maitenes, Queltehues and Volcán generating stations were put out of service by the earthquakes of 28 August and 4 September 1958. Similarly, when the Abanico power station was put temporarily out of service by the earthquake of May 1960, it was the power stations of the third zone which dispatched energy to the affected area. Economically, such transfers involve the efficient utilization not only of national resources but also of existing equipment.

When in the near future the interconnected system is extended into the fifth zone with the incorporation of the lines of the Pullinque power station (planned to come into operation in 1961), the system will function

in the following way: in summer, the surpluses of the second and third zone will be dispatched to the fifth, and in winter the transfers will go in the other direction. There will also be changes in direction of flow of power daily, owing to the predominance of storage plants in the southern zone (with larger contributions at peak hours) and run-of-river plants in the northern part of the system (base load).

The forecasting of future maximum demand is calculated on the basis of the system having an annual rate of growth of 7 per cent in the period 1959-66 and 7.5 per cent in the period 1966-72. These rates are considered the strict minima for the development of the country and will involve the doubling of supply over a period of about ten years.

(a) The concession of the Compañía Chilena de Electricidad

Brief consideration should be given, within the system that is being studied, to the area granted as a concession to the Compañía Chilena de Electricidad before proceeding with the study of overall expansion plans.

The concession of this company covers the provinces of Santiago, Valparaíso and Aconcagua with the exception of the towns of Viña del Mar and Melipilla,[39] but including the two most important towns in those provinces namely, Santiago and Valparaíso. In 1959, maximum demand was 281 MW and the power supplied amounted to 1,363 million kWh. Load and power rationing has been in use since 1946 and restrictions are placed on the admission of new subscribers and the widening of existing demand. The figures for maximum demand and the amount of power supplied represented about 47 and 60 per cent respectively of the installed capacity and of the output of the main public service undertakings in the country.

The population of the area served by the Cía. Chilena de Electricidad amounted to 2.79 million, it being estimated that about 80 per cent had electricity service. Net consumption in 1959 was 435 kWh per capita.[40]

39/ Viña del Mar is served by the Cía. Nacional de Fuerza Eléctrica and Melipilla by the Cía. Eléctrica Melipilla.

40/ It should be recalled that in 1959 the average for generation for the whole country was 285 kWh per capita, taking public service generation alone; with the addition of generation by self-suppliers the figure was 576 kWh per capita.

/In the

In the period 1950-59, the power supplied throughout the area served by the company increased at an annual average rate of 4 per cent (at which rate supply would double in about 17 years); this figure is similar to that for population growth, and this means that public service per capita consumption has remained steady over time.

In 1959, the number of subscribers was over 285,000, with an estimated average of 7.8 persons per unit.

In the same year, the percentage distribution of power by type of consumer was as follows: household 28.3, commercial 10.3, industrial 33.2, transport 13.6, State services 8.5, public lighting 4.7 and rural consumption 1.4. In 1938, when there were less or no restrictions, distribution was: household 13.1, commercial 8.7, industrial 35.8, transport 31.2, State services 4.8, public lighting 5.8 and rural consumption 0.6. An appreciable increase is to be observed in the share of household consumption. This reflects the increased use of household electric appliances resulting from increased levels of living, and at the same time a fall in the share of public transport (partial replacement of electric trams in public transport services by petrol or diesel driven vehicles). To a lesser extent, a decline is to be noted in the share of industrial consumption and an increase in the share of commercial consumption.[41/] The annual load factor fell from 0.55 in 1938 to 0.48 in 1945, to rise again to 0.55 and 0.54 in recent years.

(b) Proposed extensions

The works under way and those proposed for the period up to 1972, to meet increases in consumption in the system, can be split up between those to be carried out by ENDESA and those which are the responsibility of the Cía. Chilena de Electricidad. ENDESA is responsible for ensuring the harmonious development of electricity supply throughout the whole interconnected system (Copiapó - Puerto Montt) while the latter is responsible only for the area of its concession.

41/ The increase in manufacturing activity in the area concerned was covered in part by increased generation by self-suppliers.

(i) ENDESA: In 1959, the extension of the Abanico generating station entered into service at 135 MW - 49 MW, including the tailrace into Lake Laja with a load capacity of over 1.3 million kWh (1961).[42/] The Pullinque plant of 49 MW (1961), Isla plant 68 MW (1961), all of them hydraulic. The Huasco plant, 15 MW (1963), thermal. The Rapel plant, hydraulic, 130 MW, first and second units (1964), Rapel 130 MW, third and fourth units (1965). Lake Laja plant, hydraulic, 120 MW, first and second units, and Cuncumén plant, hydraulic, 15 MW (1966), Lake Laja 120 MW, third and fourth units, and Cuncumén 15 MW, second unit (1967), Garzas plant, hydraulic, 96 MW, first and second units, and deviation of the Alto Polcura to Lake Laja (1968), Garzas 48 MW, third unit, and extension of Huasco 15 MW (1969). Later, in the period 1970-72, it is proposed to establish two further hydraulic power stations of 270 MW and to make a second extension to Huasco of 15 MW. These plans will provide a total of 1,140 MW of new power and will provide for the parallel development of substations, transmission lines and primary distribution systems. Proposed investment amounts to 440 million dollars (36 per cent in foreign currency and the remainder in Chilean currency). For the construction of the Rapel and Huasco plants, the International Bank for Reconstruction and Development granted in January 1960 a loan of 32.5 million dollars repayable over 25 years at 6 per cent.

(ii) Cía. Chilena de Electricidad: The 1959-66 expansion plan, co-ordinated with the ENDESA plan, provides for the establishment of two thermal plants: Renca, with two turbo-generators of 50 MW each (1962), and San Antonio, on the same lines as Renca (1964). In addition, provision is made for the establishment of two sub-stations of 20 mVa each 110/12 kV at Concón and San Pedro and large numbers of transmission lines (110 kV) and medium tension

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42/ The figures in brackets represent the years in which the works concerned are planned to be put into service.

distribution lines (12 kV), cables and low tension distribution transformers. The total amount of investment provided for is approximately 100 million dollars (41 per cent in foreign currency and the remainder in Chilean currency).

(c) Trends in power prices

Trends in average prices per kWh within the concession of the Cía. Chilena de Electricidad may be related to the cost of living in the country through a study of the following indices (1938 = 100). The first figure for each year corresponds to the cost of living and the second represents the cost of the kWh: (1938) 100 and 100; (1949) 517 and 262; (1955) 3,350 and 1,310; (1958) 8,280 and 4,960. It can be seen that electricity rates have lagged very much behind the general change in price levels, although the margin has been gradually diminishing. Thus the price of electricity was 2.5 times lower in 1955 and 1.67 times lower in 1958 than the corresponding cost of living figure.

As an indication of prices in relation to other competitive sources of power in the industrial field, it should be noted that the average price of 1,000 kWh sold industrially was equal to the sales price in Valparaíso of 1,350 tons of fuel-oil No. 5 (1958) or 0.215 of diesel oil.[43/]

43/ The sources of information and material for this section included direct information supplied by ENDESA, the Cía. Chilena de Electricidad, Cía. General de Electricidad Industrial and the Sociedad Austral de Electricidad, in addition to the following publications: Producción y consumo de energía en Chile 1957, 58, 59 (ENDESA), Plan de Electrificación del País (ENDESA) and the United Nations Monthly Bulletin of Statistics, May 1960.

VII. MEXICO

1. Central interconnected system

This is the main system in Mexico; it consists of the equipment of the former Cía. Mexicana de Luz y Fuerza Motriz S.A. (CMLFM), taken over by the Government in September 1960, and the hydroelectric system Miguel Alemán, belonging to the Comisión Federal de Electricidad (CFE). Its origins go back to 1902. The original system grew up on the basis of direct concessions and the incorporation of smaller enterprises, and the territory now covered includes the Federal District and the neighbouring areas of the states of Mexico, Hidalgo, Puebla, Morelos, Guerrero and Michoacán.

This is the most important area in Mexico, from the standpoint of both population and industrial production. The average population density is 60 per square kilometre, compared with about 11.4 for the rest of the country. The value of industrial production represents approximately 65 per cent of the total for the country, and production in the Federal District alone represents 55 per cent of this total. The principal towns served outside the Federal Capital include Pachuca, Toluca, Cuernavaca and Taxco.

In 1954 the population served by this system was 4.4 million, in 298 towns and villages; in 1959 the corresponding figures were 5.6 million and 434, representing an annual cumulative growth rate of 4.9 per cent.

Average net per capita consumption was 490 kWh in 1954, and rose to about 650 kWh in 1959. There were 748,000 registered consumers in 1959, representing an average of nearly 7.5 persons per registration.

(a) Installed capacity and generation

Between 1954 and 1959 the annual growth rate of installed capacity was 9 per cent, and of generation 10 per cent. These increase considerably reduced the existing deficits in consumption and maximum demand.

In 1959 hourly maximum demand was 775 MW, and generation 4,070 million kWh, resulting in an annual load factor of nearly 0.6. In recent years there has been a slight increase in the load factor.

/Installed capacity

Installed capacity in the system is 937 MW and constituted 44.2 per cent of the public utility's total installed capacity in 1959. As regards production, the system contributed 51.5 per cent of total output by the public service as against 49.5 per cent in 1955. This indicates that the tendency for electricity production to be concentrated in the central part of the country has persisted. The frequency used is 50 cycles. The percentage distribution of energy by types of consumer in 1959 was as follows: residential 15.8, low-tension commercial and industrial 17.4, high-tension industrial and mining 52.1, tramways 5.6 and governmental services 11.2. The contraction in the share of tramways was due to the increased use of internal combustion engines in urban transport.

Energy losses in transmission, distribution and unregistered services (exclusive of consumption in the generating plants themselves) went up to 21.8 per cent in 1959. This is one of the highest figures recorded in Latin America.

The ratio of the hourly peak load dispatched to installed capacity in the generating plants (utilization factor) was higher than 0.82. It should be remembered, however, that, because of limitations in the piping, the Ixtapantongo power station has a real capacity of only 83.7 MW, instead of 105.8 which corresponds to the plate capacity, and that the largest unit in the system (the Lechería plant) is of 82.4 MW. Thus, when this unit was out of service in 1959, maximum demand exceeded available capacity.

Generation was divided as follows: hydroelectric 91 per cent (CMLFM 40.8 per cent and CFE 50.2 per cent) and thermoelectric 9 per cent.

With respect to the large proportion of hydroelectricity, energy stored in the reservoirs (Necaxa, Lerma and the Miguel Alemán system) amounted to approximately 2,600 million kWh in 1959, which constituted about 72 per cent of hydraulic production and more than 65 per cent of the total for the system.

Installed capacity in the system was divided as follows: CMLFM 62.5 per cent and CFE 37.5 per cent.

/(b) Power

(b) Power stations and lines

The main power stations are:

(1) CMLFM

(i) Hydroelectric: Necaxa 115 MW, Patla 45.6 MW, Tepxic 45 MW and Tezcapa 5.4 MW in the State of Puebla, connected with a reservoir system; Lerma 79.9 MW in Michoacán (reservoir); Alameda 8.9 MW in the State of Mexico.

(ii) Thermoelectric: Lechería 148.4 MW and Nomoalco in the State of Mexico, and Tacubaya 30.9 MW in Distrito Federal.

(2) CFE:

All hydroelectric in the State of Mexico: Tingambato 135 MW, Ixtapantongo 105.8 MW, Santa Bárbara 67.6 MW, D'Meza 25.2 MW and El Durazno 18 MW, all connected with a chain of storage plants (Miguel Alemán).

The system has transmission lines at 220, 150 and 85 kW, but all the current dispatched to Distrito Federal is at 85 kW, which may be considered as an underutilization voltage. In addition, there are lines at 60, 44, 20 and 6 kV. The line from the Necaxa group to Distrito Federal (150 km) is at 220 kV.

The lines from the Miguel Alemán system to Mexico City, which cover 260 kilometres, are at 150 kV.

There are more than 350 kilometres of line at 85 kV, 160 kilometres at 60 kV and more than 80 kilometres at 44 kV. Distribution at 20 kV is extensive.

(c) Expansion projects

Consumption in the system is projected up to 1964 at an annual cumulative growth rate of 10 per cent; this would require the installation of some 600 MW (including reserve capacity) in 1960-64.

The programme from 1961 onwards is roughly as follows: power station of 145.6 MW on the River Apulco in 1961; new thermal plant of 250 MW in two equal units in 1962 and 1963; power station Atexcaco (H) of 139.5 MW in 1964. In addition, the San Bartolo and Palmatlán (H) power stations with a total of 28 MW will be set up between 1962 and 1964.

/(d) Trend

(d) Trend of energy prices

The trend followed by the average price of the kWh in relation to the cost of living in Mexico City may be observed from the following indices, which are all based on the year 1934 and in which the first figure for each year corresponds to the cost of living and to the second to the price of the kWh: (1934) 100 and 100; (1940) 157 and 103; (1950) 556 and 257; (1955) 855 and 212; (1958) 1,058 and 242.

An indication of prices in relation to possible energy substitutes for industry is afforded by the fact that the average price of 1,000 kWh in the system in 1959 was the same as the sales price of 0.5 tons of fuel-oil, 1.3 tons of diesel-oil and 0.7 tons of coal.44/

44/ In addition to the first-hand information obtained, the following sources were consulted for this section: Revista Técnica IEM (September 1959); Generación y Distribución de Energía Eléctrica en México 1939-49; La industria de energía eléctrica (Fondo de Cultura Económica, 1953); annual reports for 1958 and 1959 of the CMLFM; Statistical compendiums for 1947, 1955 and 1958, the report of the Miguel Alemán hydraulic system for 1958; an untitled publication by the CFE; the 1956 industrial census and Empresas y Plantas Eléctricas en la República Mexicana, Bulletin 1-6.

VIII. PERU

1. System in the Lima area

The major electricity system in Peru is that which feeds the Lima area, consisting of the Rimac valley, downstream from Tamboraque, Lima and Callao and approximately 50 kilometres of the littoral to the north and south of Lima. The system belongs to the Lima Light and Power Company, Empresas Eléctricas Asociadas, whose capital is mainly of Italian and Swiss origin.

Peak demand met at the generating plants in 1959 was 155 MW and the energy generated amounted to 719 million kWh. These figures represented 48.5 and 74 per cent respectively of the installed capacity and total production of Peru's principal public electricity companies.

The area served by the system had approximately 1.75 million inhabitants in 1959 (17 per cent of the country's total population), while the urban population of Lima-Callao was estimated at 1.30 million.

In 1950-59, generation increased at the average cumulative rate of 9.4 per cent yearly, while the corresponding rate for the population was 3.7 per cent.

(a) Consumption

Net per capita consumption (exclusive of distribution losses) was 360 kWh in 1959 for the whole of the area under consideration and 490 kWh for the Lima-Callao urban group.[45/]

The number of subscribers was about 193,000, divided into the following percentages: domestic 82, commercial 14.3 and industrial 3.7, including public lighting and transport.

As 95 per cent of the urban population is supplied with electricity, the average number of inhabitants per subscriber was 6.5. The distribution of consumption in percentage terms was as follows: industrial 41.8, domestic 40.4, commercial 8.9, public lighting 5.4 and transport 3.5. In

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45/ The average for the whole country in 1959 was only 92 kWh/per capita in the case of public utility generation, the average for private generation being 210 kWh/per capita.

1948 the distribution was: industrial 40.0, domestic 33.4, transport 12.2, public lighting 7.4 and commercial 7.0. Domestic and commercial consumption has thus expanded considerably at the cost of the shares of transport and public lighting respectively.

Distribution losses were estimated at slightly more than 14 per cent in 1959.

(b) Power stations and lines

In 1959 88.4 per cent of generating capacity was hydraulic in origin and the balance was thermal. The power stations were as follows:

(i) Hydraulic: Callahuanca 67 MW (three units of 12 MW each and one of 31 MW; the latter entered into operation in 1958); Moyopampa 63 MW (three units of 21 MW each); Yanacoto 10 MW (this plant will be dismantled when the Huampaní power station enters into production); and Chosica 3 MW.

(ii) Thermal: Santa Rosa 19.5 MW (one gas-turbine unit of 10 MW, the remainder being steam-driven).

The annual load factor in the plants was 0.55 in 1959. In 1949 it was 0.57. During a working day in winter it rose to slightly over 0.62.

The ratio of the peak load dispatched to generating capacity in the plants (utilization factor) was a little over 0.94 in 1959; in other words the reserve was less than the annual increase in demand.

The frequency used is 60 cycles.

In 1959 the transmission cables measured as "single lines"[46/] amounted to 368 kilometres at 64 kV and 120 kilometres at 30 kV. Medium-voltage distribution took place at 10 and 2.3 kV and low-tension distribution at 220 kV, with three conductors.

In 1959 installed capacity in transformers and the installed consumer load in relation to generating capacity were 1.50 and 3.9 respectively.

46/ In the data provided by the Lima Light and Power Co., 1 kilometre of double circuit is assumed to represent 2 kilometres and 1 of triple circuit 3 kilometres.

The percentage distribution of the company's assets in 1959 was as follows: generating plants 32.7, transmission lines 12.2, distribution system 41.5, works in execution 8.8 and miscellaneous 4.8.

(c) Plans

In accordance with the National Electrification Plan,[47] the forecasts of peak demand were made on the basis of a growth of rate of 7.5 per cent higher than the peak demand recorded in 1955, and a load factor of 0.515.

In August 1960, the Huampani hydro plant (30 MW), 6 kilometres downstream from the Yanacoto power station, entered into production (first stage) and the Marcapomacocha diversion is already under way. By this means it will be possible to divert water from the Santa Eulalia on the Atlantic side to the Pacific side. The purpose of the diversion is to increase the guaranteed power and production of existing plants, expand the capacity of plants to be constructed and extend irrigation works in the Lima pampas. It is expected to enter into operation in 1961. Two groups of 10 MW (gas turbines) are also to be installed in 1961, and it is planned that the Huinco plant (240 MW) will gradually enter into operation between 1963 and 1970.

(d) Comparative price per kWh

The development of the average price per kWh in the system in relation to the cost of living in Peru is indicated by the following indices (1950=100), in which the first figure for each year is the cost of living index and the second the average kWh price index:[48] 1950, 100 and 100; 1955, 142 and 124; 1958, 174 and 158; 1959, 196 and 162. These figures show how the average price of electricity has lagged behind the increase in the cost of living.

With respect to the price of electricity in relation to that of other sources of energy in industry, the average industrial price of 1,000 kWh in

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47/ Undertaken by the Ministry of Development and Public Works (Ministerio de Fomento y Obras Públicas in co-operation with Electricité de France (1957)

48/ Information from the Lima Light and Power Co.

December 1959 after the price increases,[49] equalled that of 0.66 tons of coal, 0.49 tons of diesel oil and 0.57 tons of industrial petroleum.[50]

49/ On 26 July 1959 the prices of petroleum and its derivatives, which were lower than on the world market, rose to an extent that resulted in the average price of 1,000 kWh for industry being approximately equal to the price of 0.60 tons of fuel oil.

50/ Sources for this section: Plan de Electrificación Nacional, Ministerio de Fomento y Obras Públicas; Estadística de los Servicios Eléctricos del Perú, Ministerio de Fomento y Obras Públicas; 1959 statistics of the Lima Light and Power Co., and direct information.

IX. URUGUAY

1. Montevideo-Rio Negro system

This is the largest system in Uruguay. It supplies the city of Montevideo and the west-central area of the country, where the population is estimated as close to 2.1 million, of which it is believed that about 1.6 million are supplied with electricity by this system.

The system belongs to the Usinas y Teléfonos del Estado (UTE), a government body.

(a) Consumption trends

In 1958 net per capita consumption was about 620 kWh, while for the country as a whole it was about 380 kWh. During the period 1950-58 the annual cumulative growth rate of consumption in the system was 8.3 per cent, less than the national average of slightly over 9 per cent.

Total maximum demand recorded at the generating stations was about 256 MW (1958); the annual increase during the previous five years was 11 per cent.

Consumption by type of consumer was approximately as follows: industrial 45.4 per cent, domestic 39.0 per cent, commercial 9.3 per cent, transport 3.3 per cent and other 3.0 per cent.

The annual cumulative growth rate for the period 1948-58 by type of consumer was approximately as follows: industrial 7.8 per cent, domestic 10.8 per cent, commercial 7.0 per cent, transport (no information), other 9.5 per cent.

Consumption by type of consumer expressed as a percentage of the consumption for the public service for the country as a whole was as follows: industrial 72 per cent, domestic 75 per cent, commercial 86 per cent, transport 100 per cent and other 73 per cent.

The annual load factor in 1958 was 0.52, compared with 0.55 in 1954.

(b) Installed capacity and generation

Power generated in 1958 amounted to approximately 1,236 kWh, slightly over 94 per cent of the total for the country, whereas in 1950 this proportion was less than 89 per cent. The nominal generating capacity for the system was 298 MW, about 90 per cent of the total for the country.

/Nominal installed

Nominal installed capacity exceeded maximum demand in 1958 by 16 per cent. The plant factor was 0.45, compared with 0.33 in 1950. In 1946 hydroelectric power constituted 33.8 per cent of the total for the system; in 1950 it rose to 96.3 per cent, but fell to 65.3 per cent in 1958. The plant factor at the Rincón del Bonete hydraulic plant in 1958 was 0.68, which was the highest value to date.

(c) Plants and lines

The following plants supply power to the system:

Plant	Type	Installed capacity (MW)	Power generated in 1958 (Millions of kWh)	Date installed
Rincón del Bonete	Hydraulic	128	760	1945-48
Batlle and Ordoñez	Thermal	150	395	1932-55-57
Santiago Calcagno	Thermal	20	9	1931
Rincón de Baygorria	Hydraulic	108	(Began generating in June 1960)	1961

The length of the main triphase transmission lines is as follows: 150 kV, 521 kilometres; 110 kV, 663 kilometres; 60 kV, 48 kilometres, and 30 kV, 86 kilometres.

The generating frequency is 50 cycles, and low tension distribution is triphase at 220/127 V.

(d) Main projects for the system

The Rincón de Baygorria plant has already begun operating, and the following plants are under study:

Hydraulic

(i) Paso del Puerto, 160-180 MW, annual average generating capacity 750 million kWh

(ii) Yapeyú, 110 MW, annual average generating capacity 460 million kWh

(iii) Salto Grande, 750 MW, a joint project with Argentina, which is also to have 750 MW.

/Thermal

Thermal

(i) Supercentral térmica 500 MW, at Rincón del Cerro (Punta del Tigre) in Montevideo

(ii) Expansion of the Valle plant and installation of a peaking plant (gas turbine) of the order of 50 MW.[51]

51/ Sources for this section: Various reports and publications of UTE.

X. VENEZUELA

1. Caracas system

Venezuela's principal electricity system is that feeding Caracas, La Guaira, Guarenas and part of the State of Miranda. It belongs to a joint stock company known as La Electricidad de Caracas.

In 1959 the population of the area served by this system was estimated at 1.2 million inhabitants (19 per cent of the total population of Venezuela), with an average density of about 645 inhabitants per square kilometre.

A considerable number of important industries (textiles, foodstuffs, beverages, chemicals, rubber products, metallurgical and metal transforming industries, etc.) is concentrated in the area, especially in the Miranda district, and intensive financial and commercial activity is also carried on.

(a) Characteristics of consumption

The maximum demand satisfied by the generating plants in 1959 was 253 MW, no restrictions of any kind being applied, and the energy generated amounting to 1,187 million kWh. These figures represented approximately 29.6 and 42.4 per cent, respectively, of the installed capacity and total output of the main Venezuelan public utility companies. (The substantial difference between the two values is due to the fact that in 1959 there were 150,000 kW of installed capacity in the Macagua-Caroní power station not yet producing energy.)

Net per capita consumption, discounting distribution losses and the consumption of the plants themselves, was 840 kWh in 1959, as against a national average of 580 kWh per inhabitant (including activities generating their electricity supply).

During the fifties, generation increased at an annual cumulative rate of 16.9 per cent, while the growth rate of the population was 7.1 per cent.

The number of subscribers stood at almost 128,000 whence it may be estimated that 95 per cent of the population has electricity laid on at home, and that on an average one out of every 8.8 inhabitants is a subscriber.

/No information

No information is available on the break-down of consumption by types of consumer, but 95.9 per cent of the subscribers registered in 1959 were listed by the company under "light" and the remaining 4.1 per cent under "power".[52/] For the country as a whole, public utility distribution is estimated at 40 per cent industrial and 60 per cent household. In the case of Caracas, forecasts for 1968 show figures of 20 per cent for industrial and 80 per cent for household plus commercial consumption, thus revealing a definite predominance of the use of electricity as an end good, in contrast to other important systems where a higher percentage is represented by consumption of electricity as a production factor.

The trend followed by the annual load factor can be traced in the following figures: 0.46, 0.48 and 0.52 in the years 1938, 1949 and 1959, respectively. On a winter working day (December 1959), the daily load factor reached 0.62. The seasonal variation in demand does not exceed 8 per cent as between summer and winter.

(b) Power stations and lines

Installed capacity amounted to 341 MW as at the end of 1959. The ratio between the maximum load dispatched and the capacity of the generating plants was 0.74. In view of its margin of reserves, this system can be favourably compared with others as regards the reliability of the service. Due allowance must be made, however, for the substantial increment which must be reckoned with from one year to another. During the period 1955-59, the cumulative annual rate of increase was 14.5 per cent.

Approximately 97 per cent of the power generated was thermal and 3 per cent hydroelectric.

The following is a list of the power stations:

(i) Arrecifes, which has an installed capacity of 164 MW constituted by steam turbines (one of 50 MW brought into service in 1951

52/ A major consumer is the National Institute of Sanitary Engineering (Instituto Nacional de Obras Sanitarias - INOS), which uses electricity for pumping water into the reservoir known as "La Mariposa", and purchased over 10 million kWh in 1958.

/and three

and three of 38 MW which entered operation in 1953, 1955 and 1959), and is linked to Caracas by a 69-kV line 24 kilometres long;

(ii) Tacoa, with two 40-MW units operated by steam turbines of which the installation was completed in 1956 and 1957;

(iii) La Guaira, with 34 MW (steam turbines);

(iv) El Convento, with two gas turbines totalling 45 MW, which entered operation in 1958 and 1959 and are used mainly to cover the increase in demand at peak hours; and

(v) El Cortijo, a 5-MW diesel plant which has been sold to the Compañía Anónima de Administración y Fomento Eléctrico (CADAFE), as weel as several hydroelectric plants with approximately 13 MW, some of which are about to be closed down.

In 1959 the transmission and distribution lines consisted of 180 kilometres of 230-kV and 69-kV lines, 355 kilometres at 30 kV, 1,080 kilometres at 4.8-8.3 kV (4 conductors), and, as regards low-tension distribution, 2,700 kilometres at 120-208 volts (4 conductors).

The frequency used is 50 cycles per second, while systems in the rest of the country, especially those of CADAFE, operate at 60 cycles. It is assumed that at the close of the sixties, after the entry into service of the Guri hydroelectric plant on the Caroní, interconnexion with that system will probably be desirable and conversion to the other frequency will therefore be effected.

The distribution of fixed assets as at the end of 1959 was as follows: power stations, 46 per cent; high-tension system, 23 per cent; distribution system, 20 per cent; and other assets, 11 per cent.

(c) Works under construction and projected

The immediate programme was formulated with a view to maximum loads of 315 and 462 MW for the years 1961 and 1965, and sales of energy amounting to 1,300 and 2,640 million kWh, respectively.

The engineering works to be carried out comprised the expansion of the Tacoa plant by the addition of 4 new units of 60 MW each, one to be brought into service in 1960, two in 1961, and the last in 1962. Between 1962 and 1965 two other units similar to the foregoing will probably be installed, and a project is under study for

/constructing - also

constructing - also by stages - a new power station at Puerto La Cruz after 1965, with a final capacity of 1,000 MW.

With respect to new lines, construction plans include the following, for entry into service in the years given: 1960, 14 kilometres at 220 kV and 10 kilometres at 69 kV; 1961, 30 kilometres at 220 kV; and in 1963, 42 kilometres at 220 kV, plus two underground cables of 100 MVA each and 69 kV, between Cota Mil and Santa Rosa, and others of 50 MVA between Convento and Chacao. The approximate cost of this plan of works up to 1963 is estimated at 100 million dollars, of which 31 per cent corresponds to investment in local currency and the balance to foreign exchange investment.

(d) Energy price trends

The trend of average prices per kWh in this system, in relation to the cost of living in Venezuela, may be studied by means of the following indices (base year 1949 = 100), in which the first figure given for each year corresponds to the cost of living[53/] and the second to the price per kWh:[54/] 1949, 100 and 100; 1955, 102 and 87; and 1959, 111 and 82.[55/]

The extent to which the average price of electricity has lagged behind the cost-of-living index seems less marked in this system than in those of other Latin American countries. As a price indicator in relation to the possible substitution of other sources of energy in the industrial field, it may be noted that the price of 1,000 kWh in the industry sector (in 1959) was equivalent to the sales price of 0.29 tons of fuel oil or 0.46 tons of diesel oil.

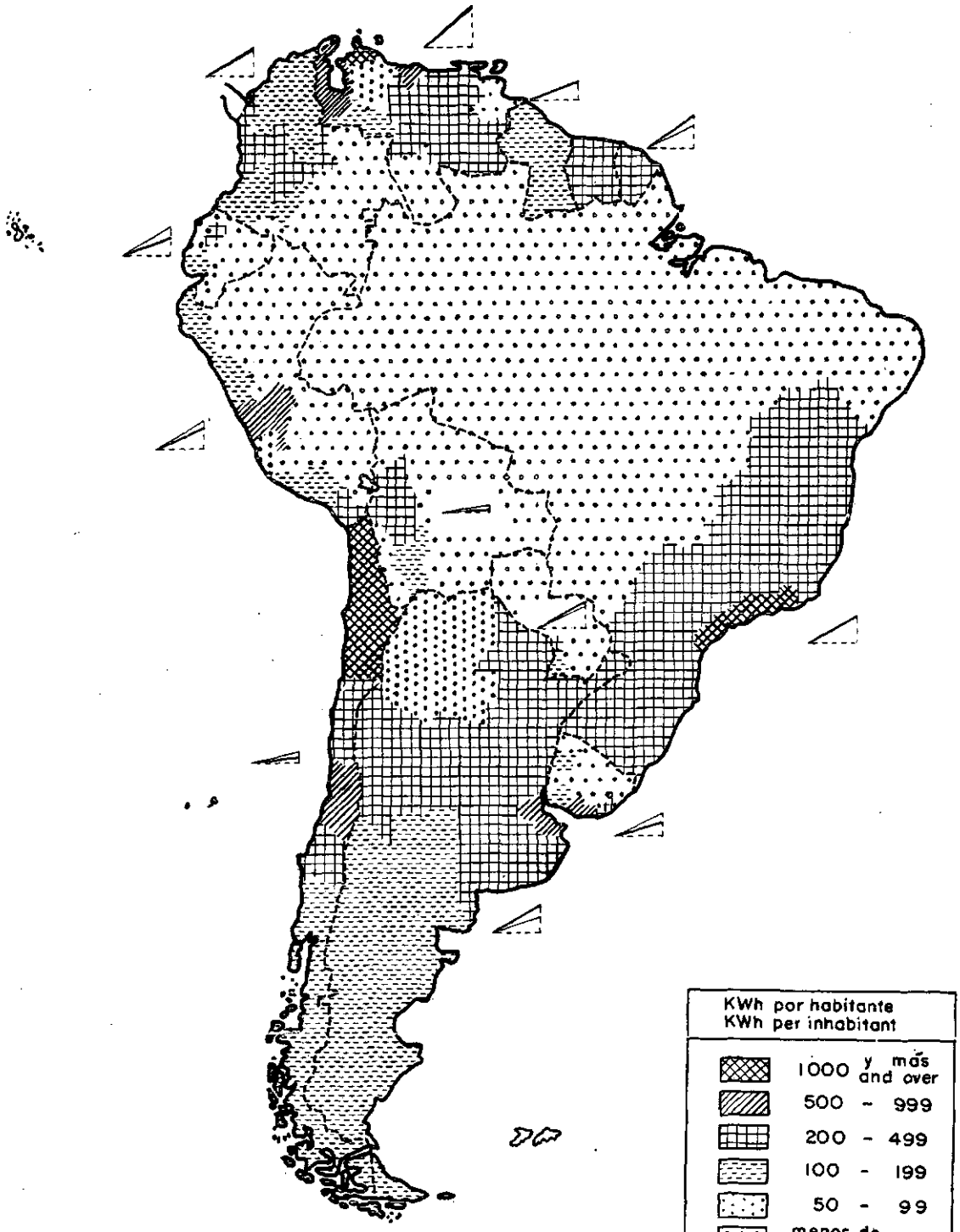
53/ United Nations, Monthly Bulletin of Statistics.

54/ Compañía Anónima La Electricidad de Caracas.

55/ Sources for the present section: Compañía Anónima La Electricidad de Caracas, direct information, and Memorias for 1958 and 1959; and Venezuelan Development Corporation (Corporación Venezolana de Fomento), National Electrification Plan, formulated for CADAFE.

GRAFICO X
FIGURE X

AMERICA LATINA: PRODUCCION DE ENERGIA ELECTRICA POR REGIONES, 1959
LATIN AMERICA: ELECTRIC ENERGY PRODUCTION BY AREAS, 1959



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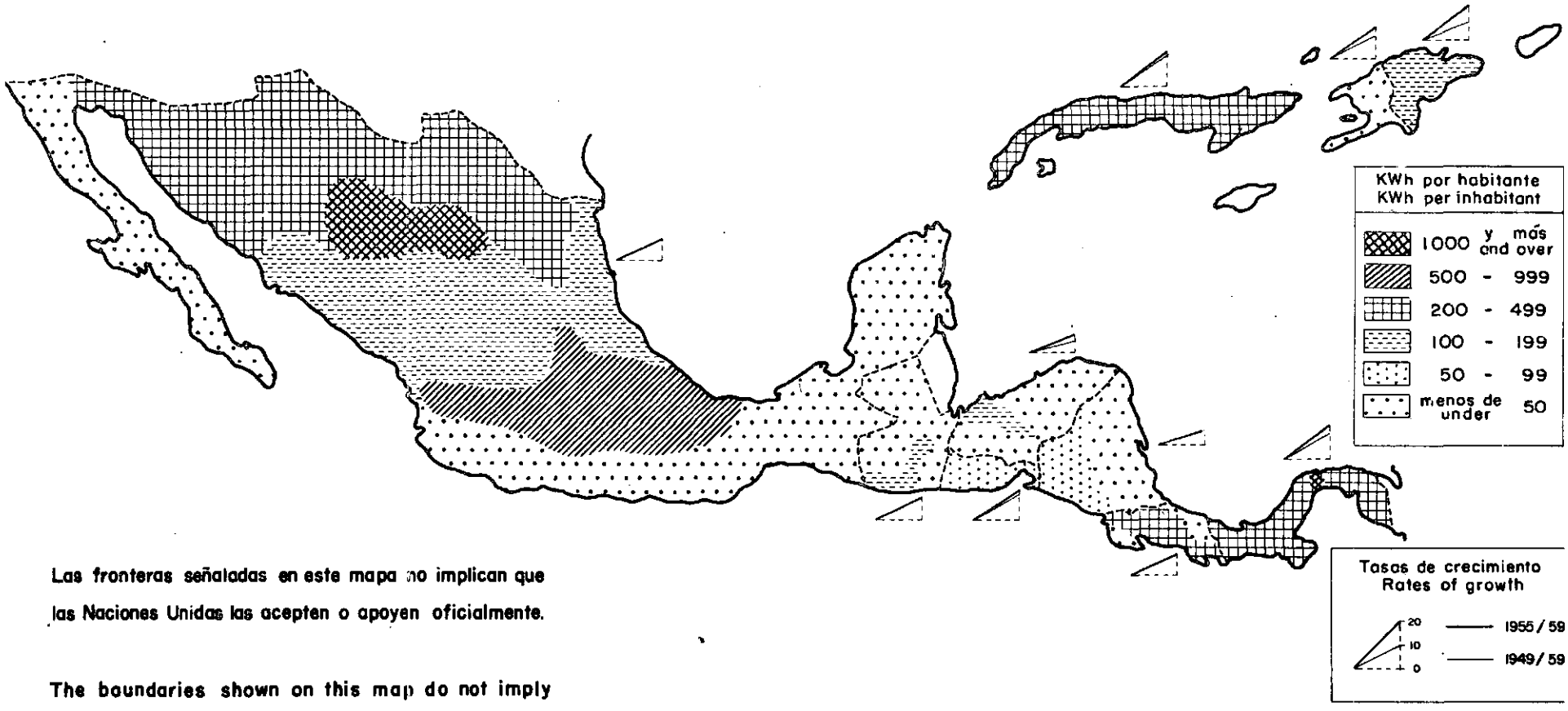
The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

GRAFICO XI
FIGURE XI

AMERICA LATINA: PRODUCCION DE ENERGIA ELECTRICA POR REGIONES, 1959
LATIN AMERICA: ELECTRIC ENERGY PRODUCTION BY AREAS, 1959



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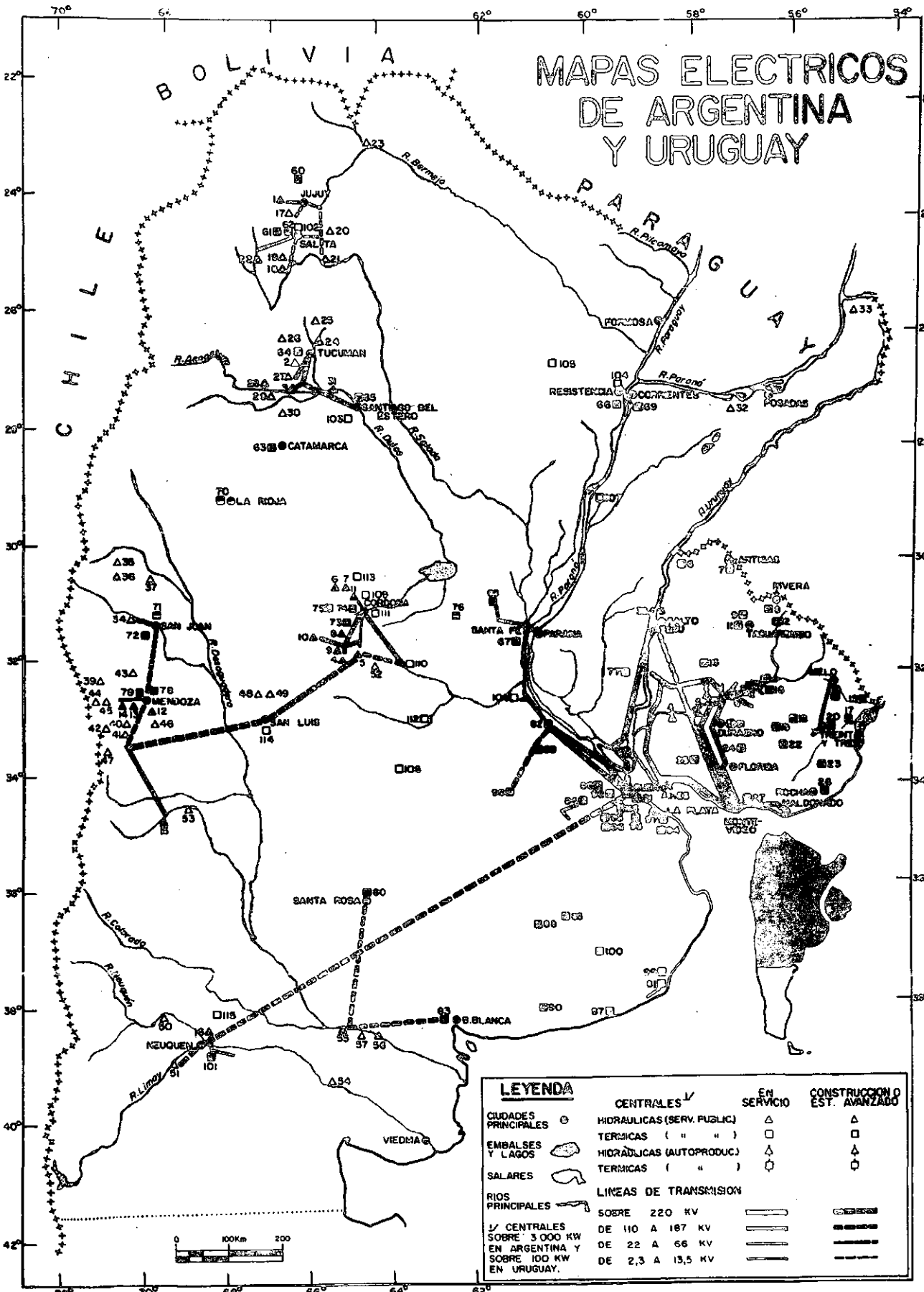
The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAPAS ELECTRICOS DE ARGENTINA Y URUGUAY



LEYENDA

CIUDADES PRINCIPALES

EMBALSES Y LAGOS

SALARES

RIOS PRINCIPALES

1/ CENTRALES SOBRE 3 000 KW EN ARGENTINA Y SOBRE 100 KW EN URUGUAY.

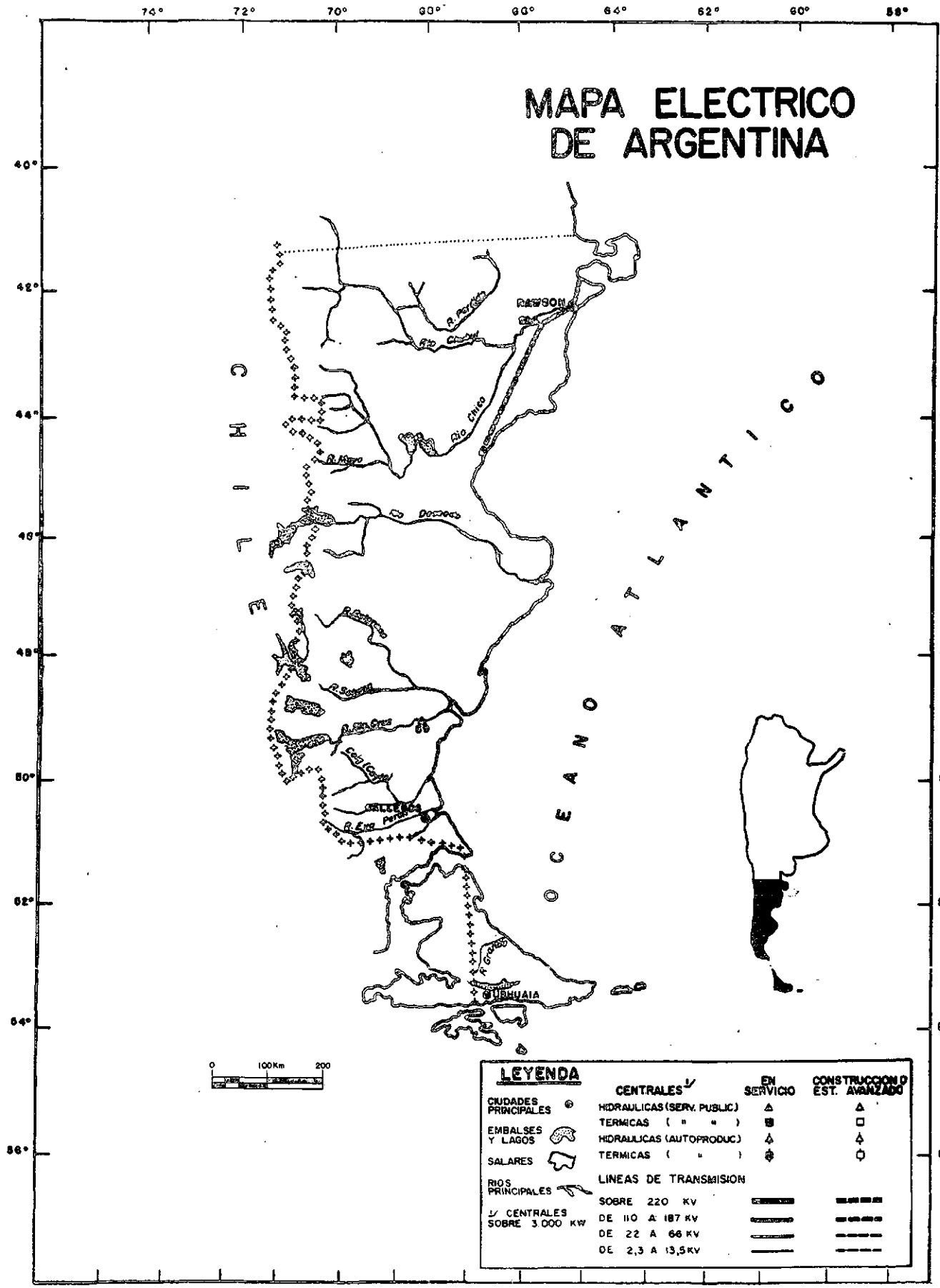
CENTRALES 1/	EN SERVICIO	CONSTRUCCION O EST. AVANZADO
HIDRAULICAS (SERV. PUBLIC.)	△	△
TERMICAS (" ")	□	□
HIDRAULICAS (AUTOPRODUC.)	△	△
TERMICAS (" ")	⬡	⬡

LINEAS DE TRANSMISION

	EN SERVICIO	CONSTRUCCION O EST. AVANZADO
SOBRE 220 KV		
DE 110 A 187 KV		
DE 22 A 66 KV		
DE 2,3 A 13,5 KV		

Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: Argentina, CEPAL a base de informaciones de Plan de Energía Eléctrica de la D.N.E. y otros; Uruguay, CEPAL a base de informaciones de U.T.E.

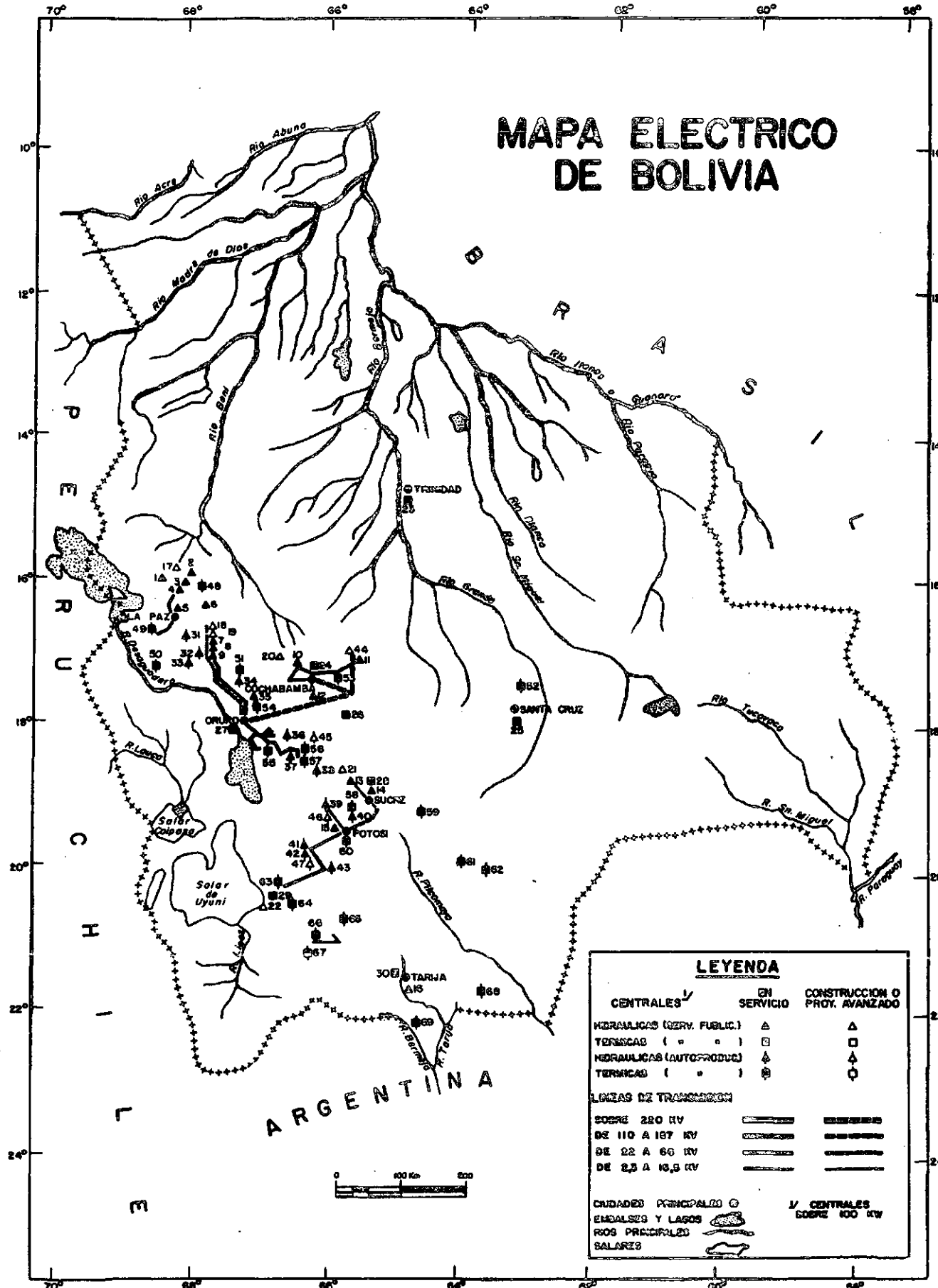
MAPA ELECTRICO DE ARGENTINA



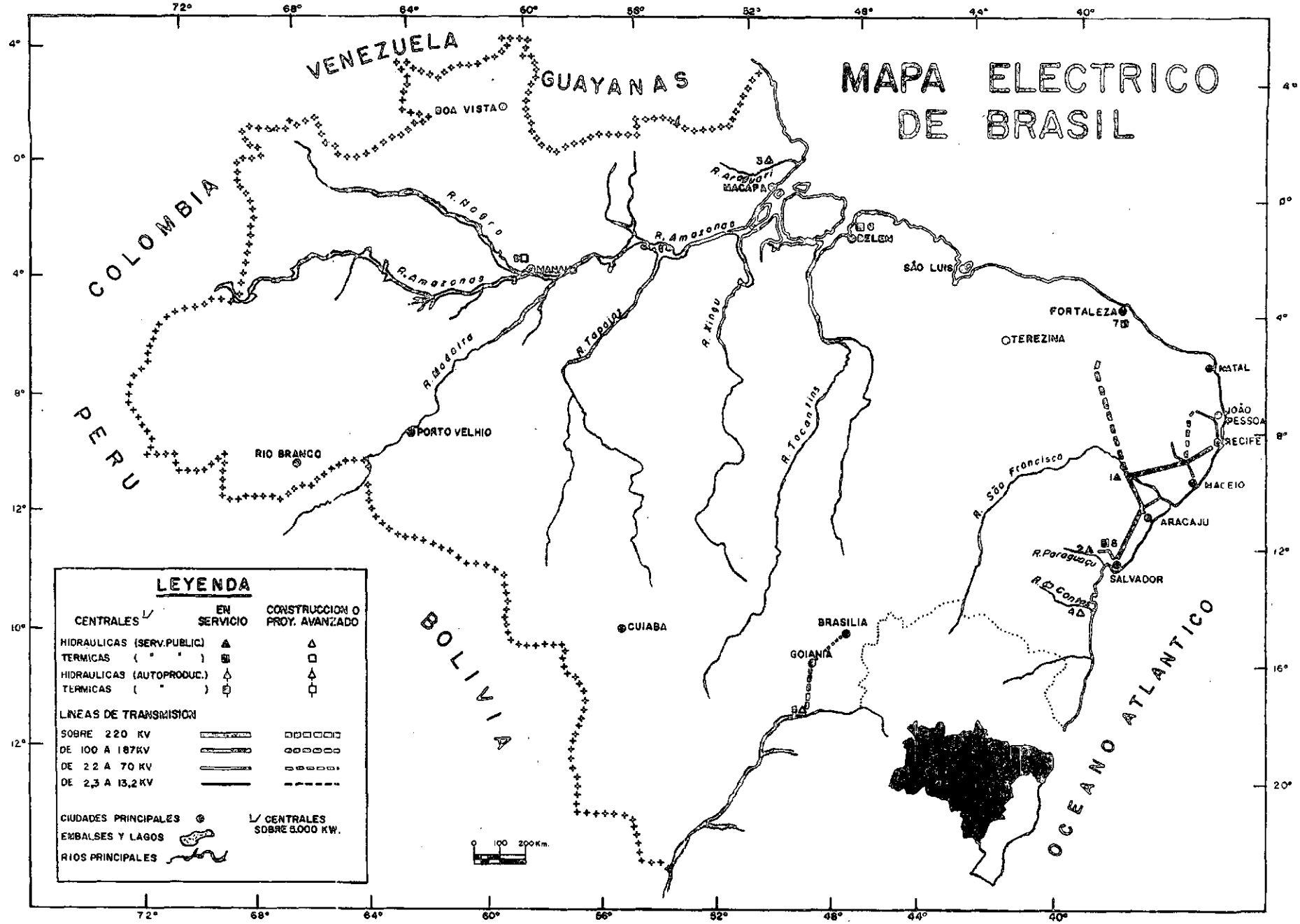
Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyan oficialmente.

Fuente: CEPAL a base de informaciones del Plan de Energía Eléctrica de la D.N.E., Agua y Energía Eléctrica, Boletín Estadístico

MAPA ELECTRICO DE BOLIVIA



Los fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL o base de informaciones de la D.G.H.yE, Corporación Boliviana de Fomento, Bolivian Power Co. y otros.



Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente

Fuente: CEPAL o base de informaciones de Plano de Desenvolvimento Económico (1957), Plano de Electrificaçao do Estado de Sao Paulo y otros

MAPA ELECTRICO DE BRASIL

LEYENDA

CENTRALES	EN SERVICIO	CONSTRUCCION O PROY. AVANZADO
HIDRAULICAS (SERV.PUBLIC)	△	△
TERMICAS (" ")	■	□
HIDRAULICAS (AUTOPRODUC)	▲	△
TERMICAS (" ")	●	○

LINEAS DE TRANSMISION

SOBRE 220 KV	▬▬▬
DE 100 A 187 KV	▬▬▬
DE 22 A 70 KV	▬▬▬

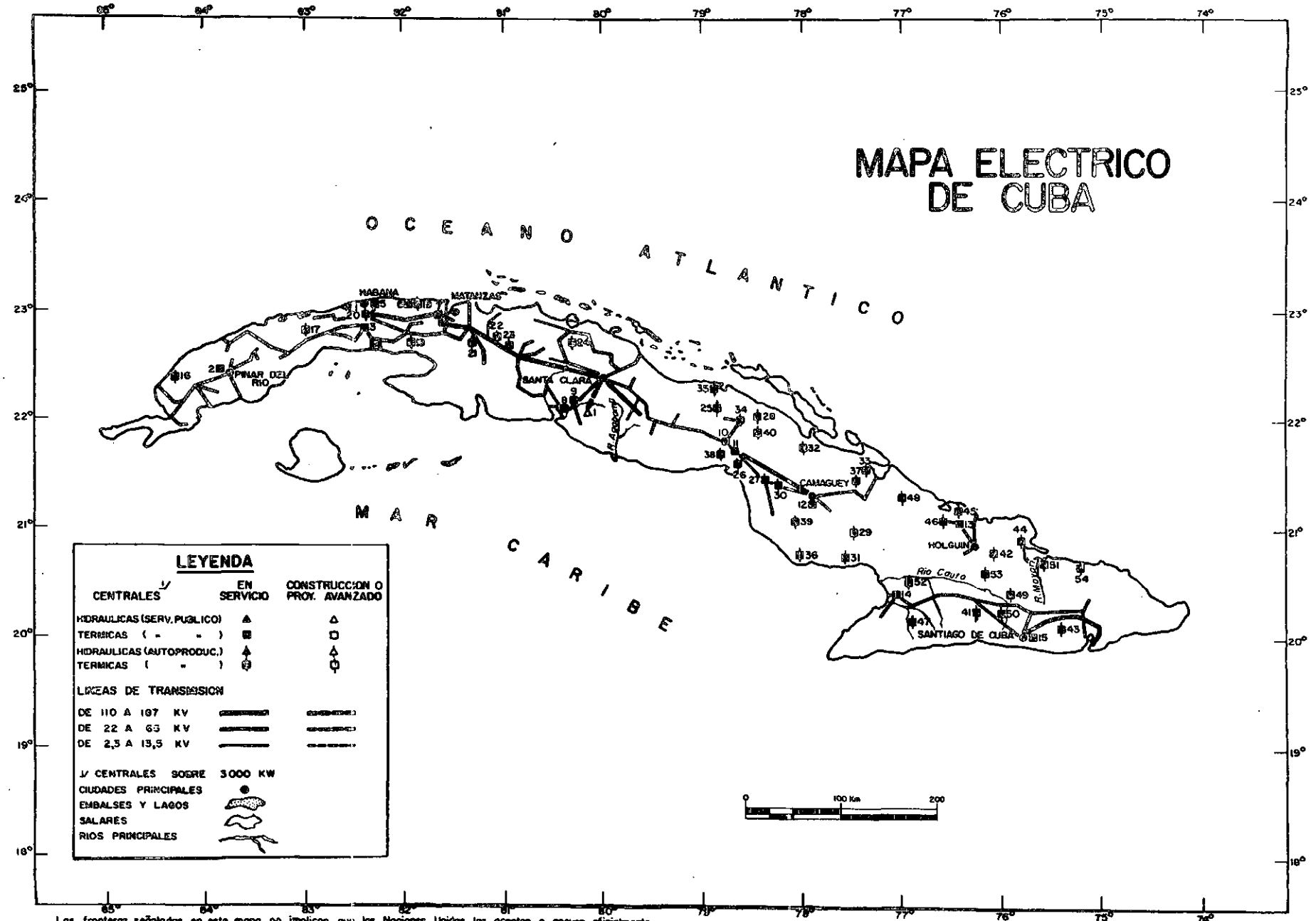
CIUDADES PRINCIPALES ⊙
EMBALSES Y LAGOS
RIOS PRINCIPALES

// CENTRALES SOBRE 5.000 K.W.

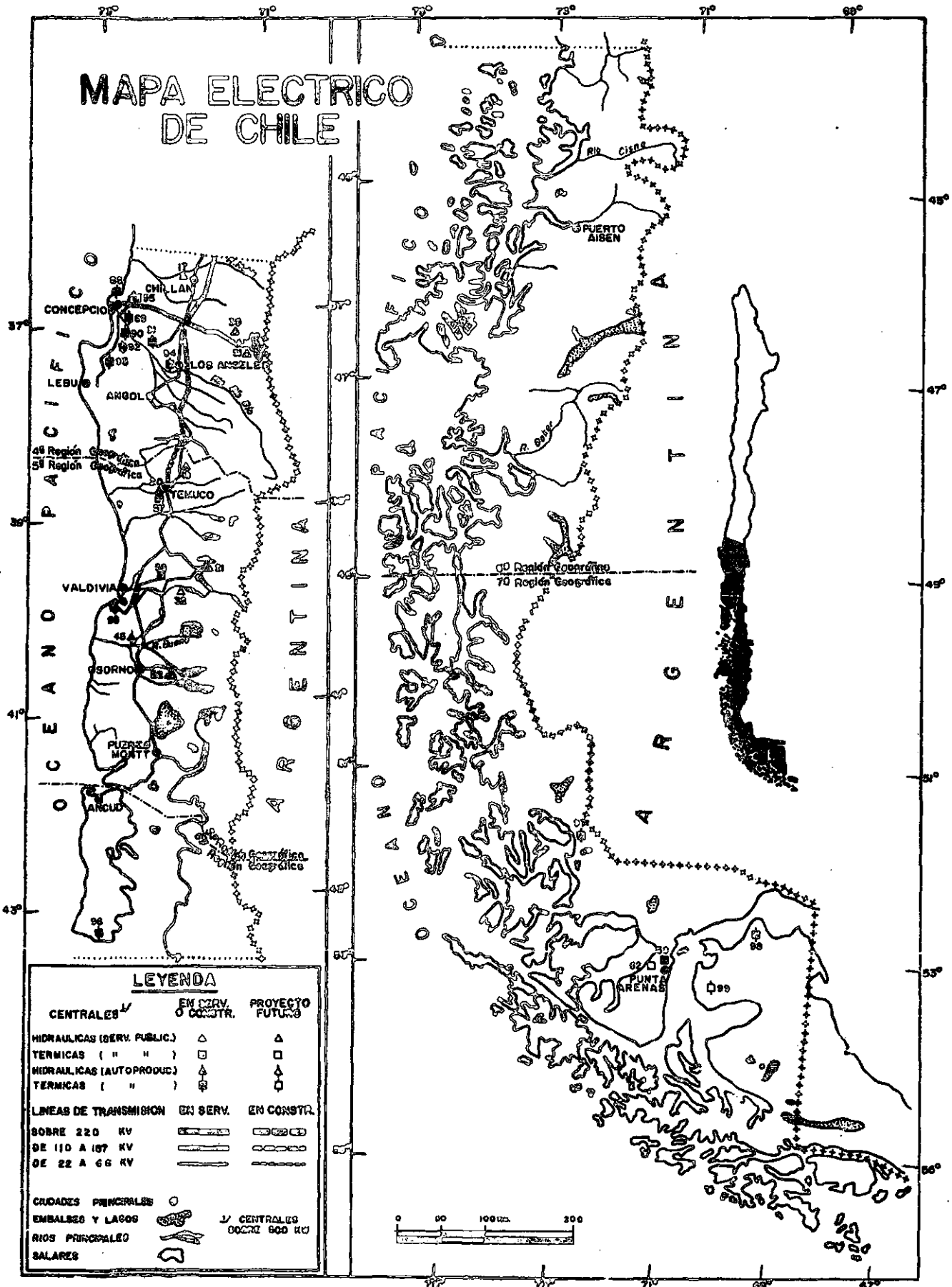
Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente

Fuente: CEPAL a base de informaciones de Plano de Desenvolvimento Económico, (1957) Plano de Electrificação do Estado de São Paulo y otros.

MAPA ELECTRICO DE CUBA

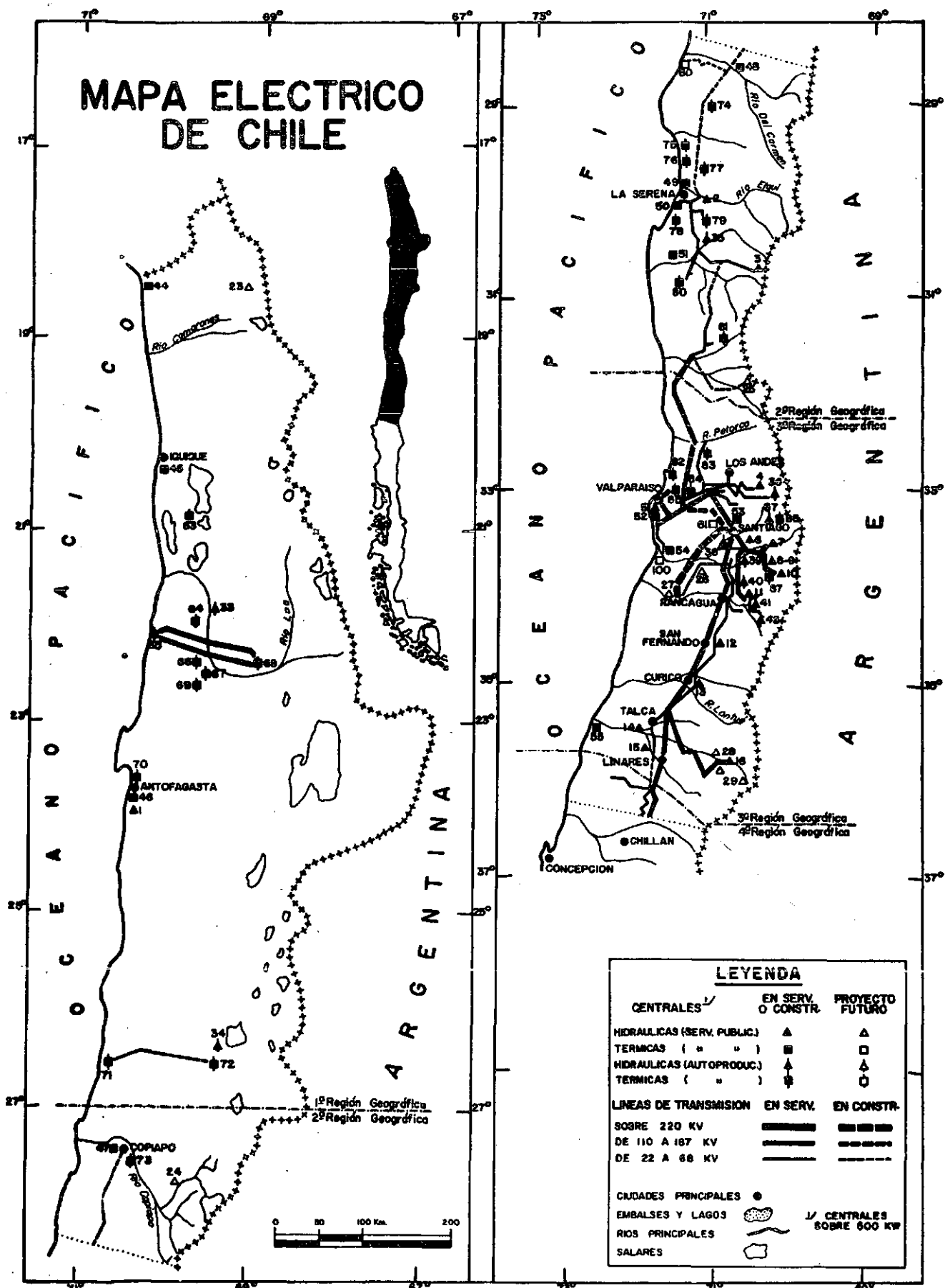


Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL a base de informaciones de Junta Nacional de Planificacion Revolucionaria; Energia Eléctrica, Consumo, Producción y Potencia Instalada.



Las fronteras señaladas en este mapa no implican que los Recursos Unidos las acepten o apoyen oficialmente.
Fuente: CEPAL a base de informaciones de ENDESA, Cía. Chilena de Electricidad y otros.

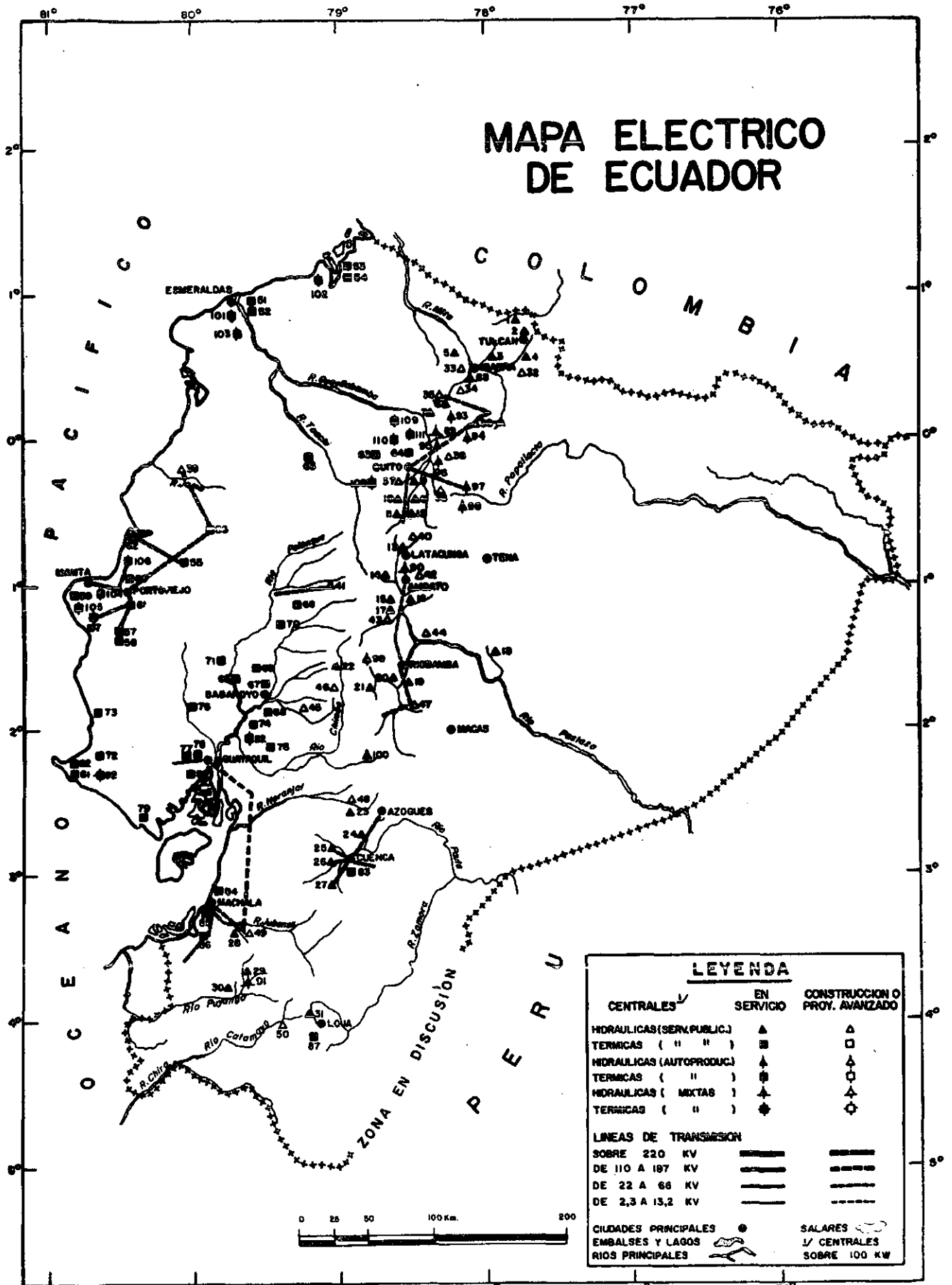
MAPA ELECTRICO DE CHILE



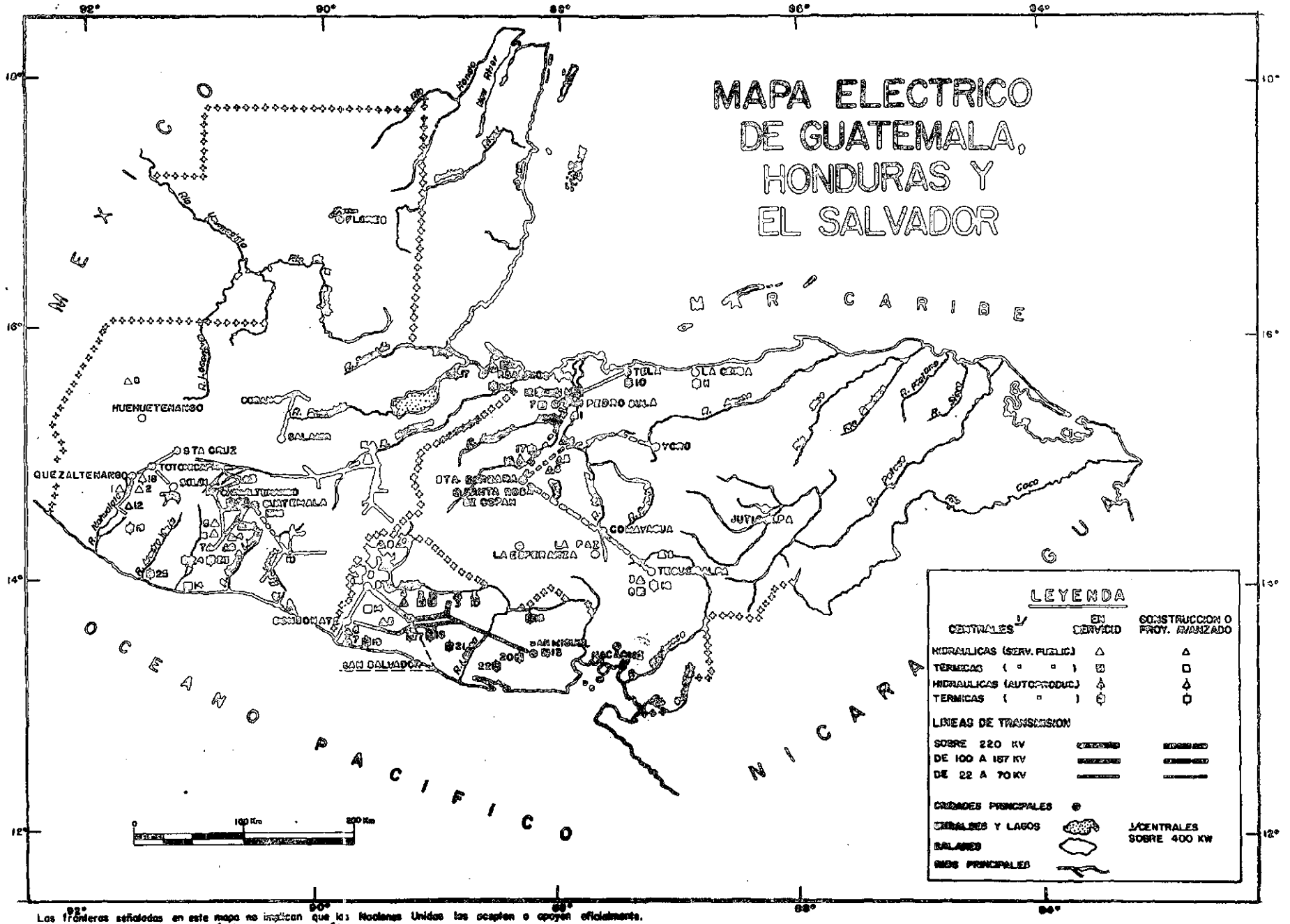
Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.

Fuente: CEPAL a base de informaciones de ENDESA, Cía. Chilena de Electricidad y otros.

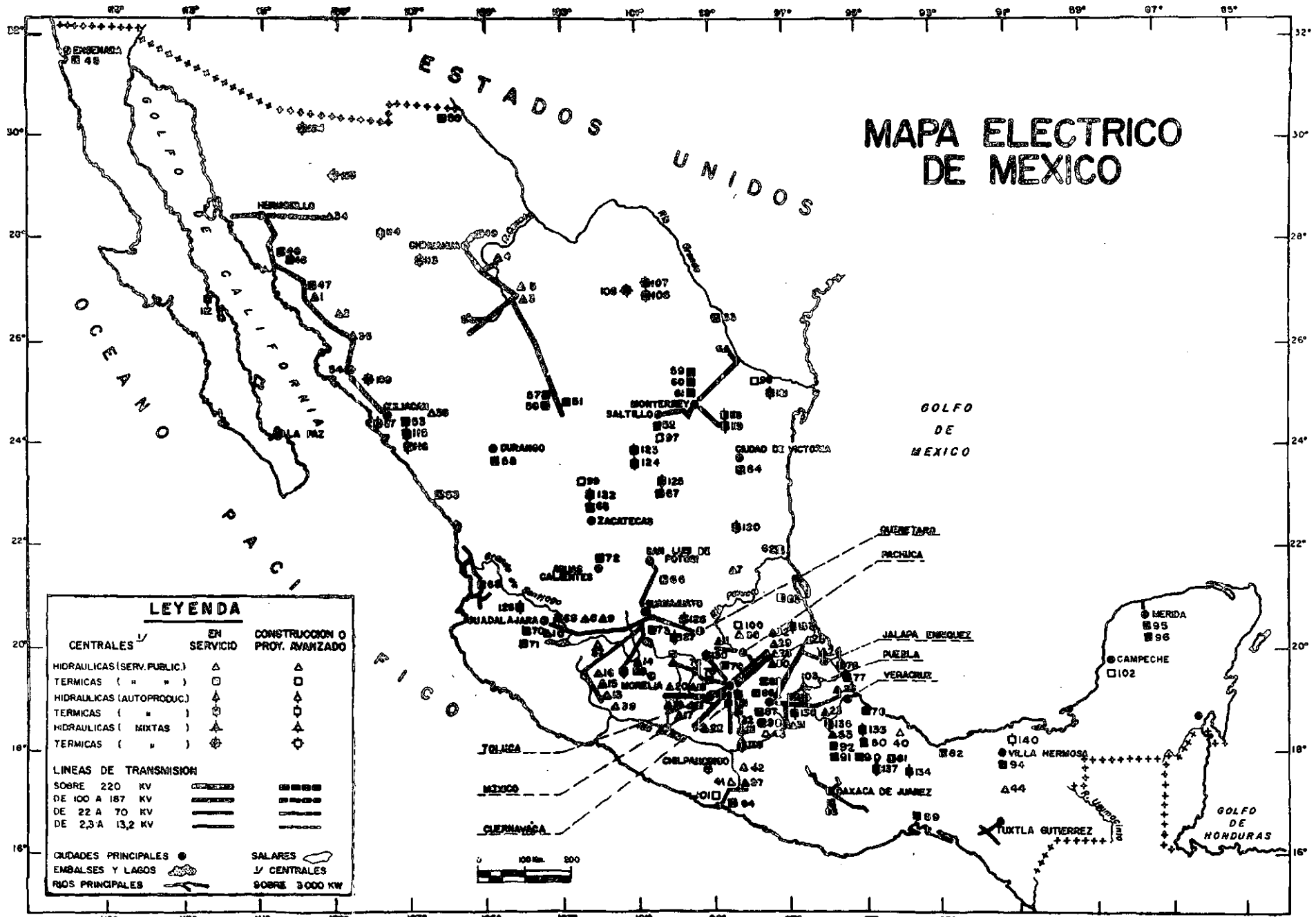
MAPA ELECTRICO DE ECUADOR



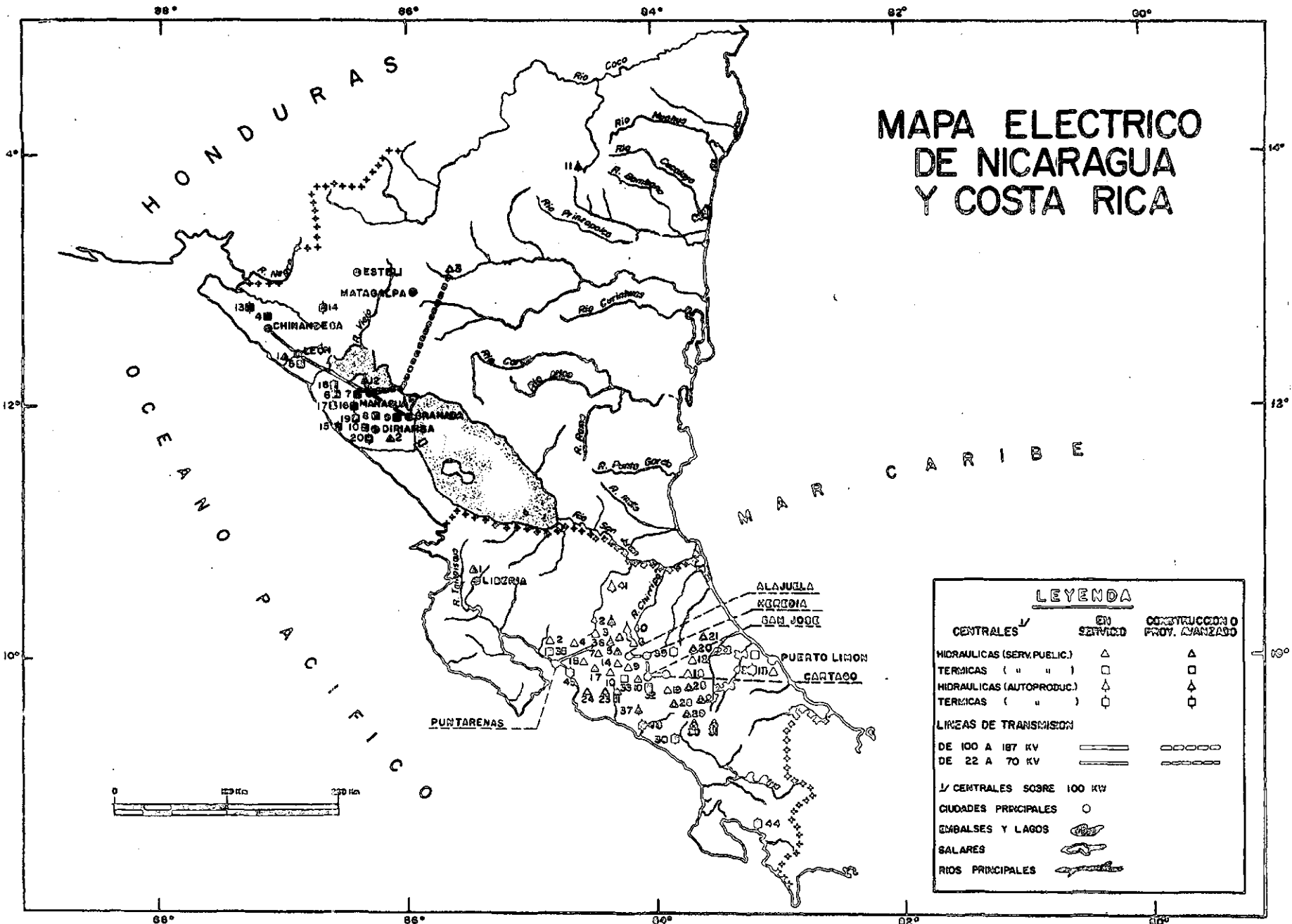
Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL a base de informaciones Junta Nacional de Planificación y otros.



Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL, el Desarrollo Eléctrico en Centroamérica.

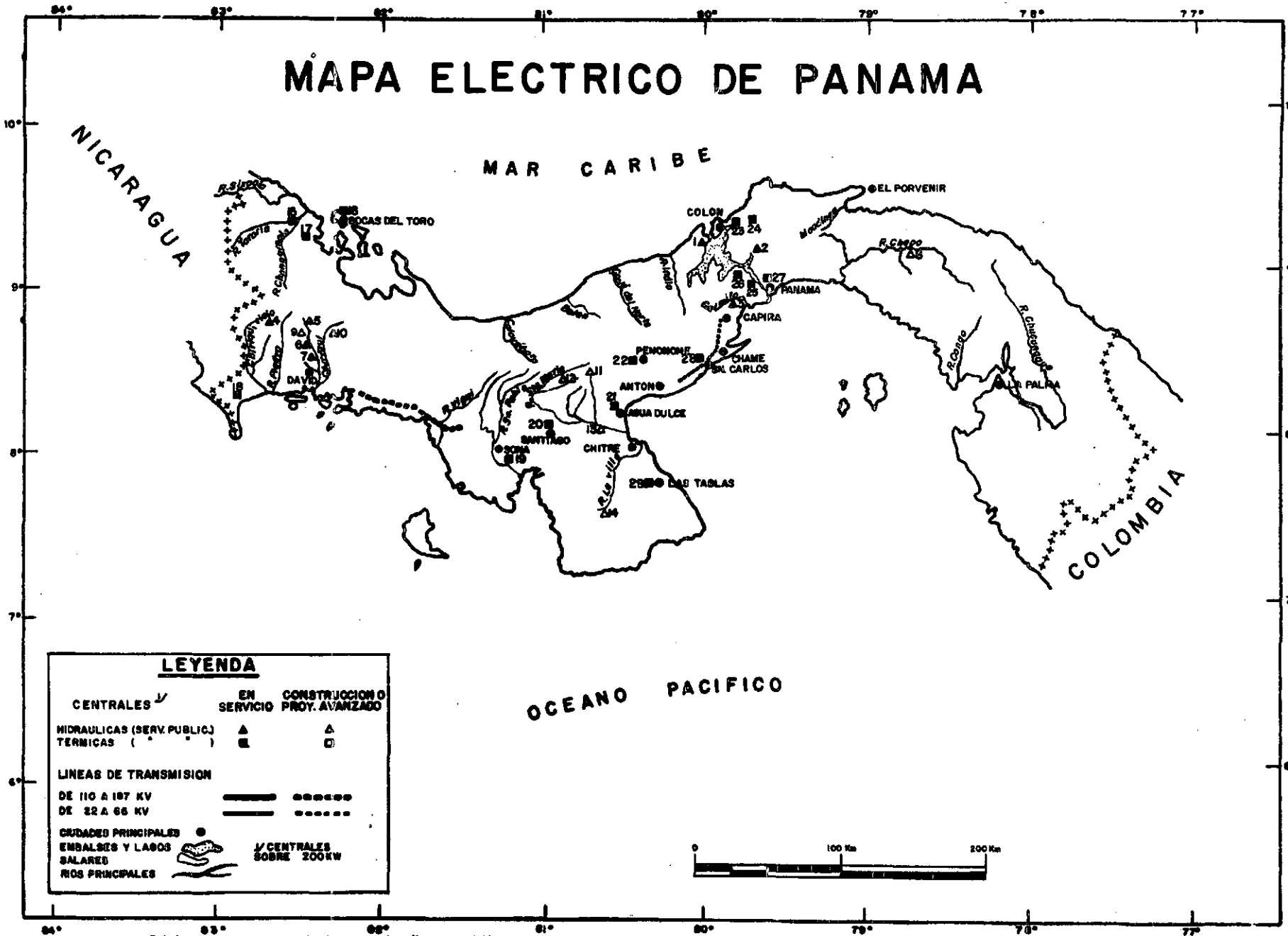


Los fronteras señalada en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL o base de informaciones de la Comisión Federal de Electricidad y Dirección General de Electricidad.



Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL el Desarrollo Eléctrico en Centroamérica.

MAPA ELECTRICO DE PANAMA



LEYENDA

CENTRALES	EN SERVICIO	CONSTRUCCION O PROY. AVANZADO
HIDRAULICAS (SERV. PUBLIC.)	▲	△
TERMICAS (" ")	■	□

LINEAS DE TRANSMISION

DE 110 A 187 KV

DE 22 A 66 KV

CIUDADES PRINCIPALES ●

EMBALSES Y LAGOS

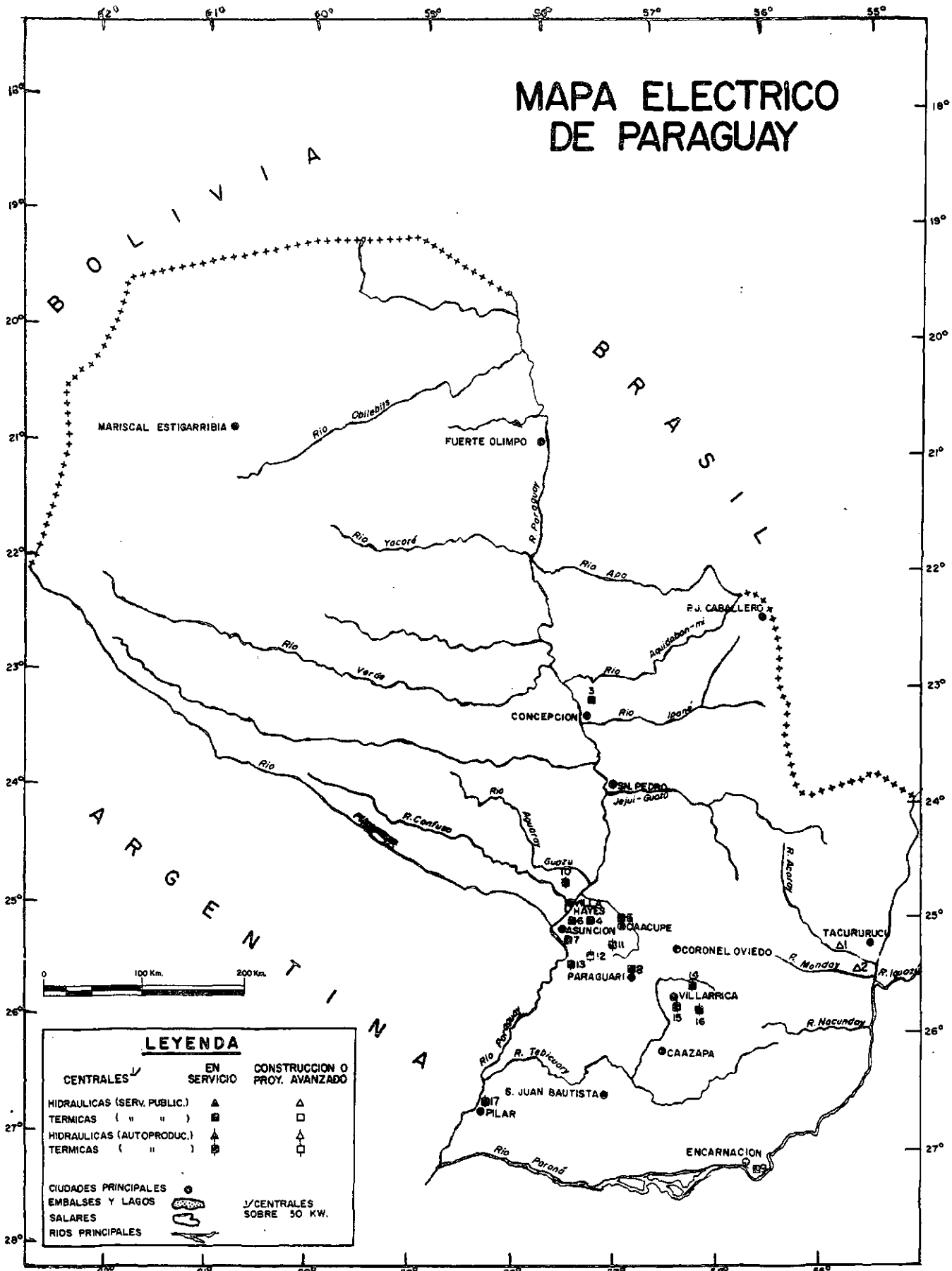
SALARES

RIOS PRINCIPALES

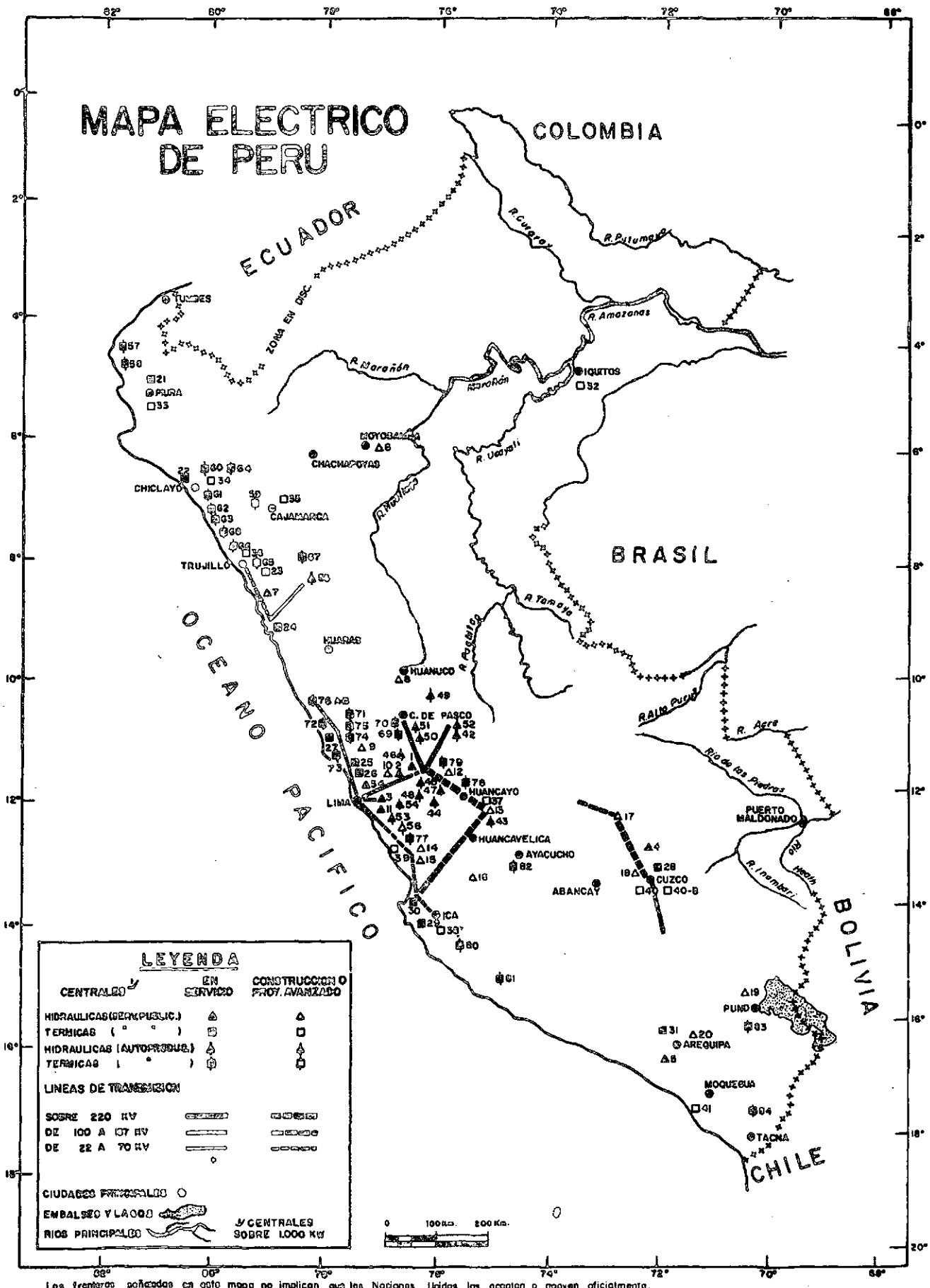
√ CENTRALES SOBRE 200 KW

Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.

Fuente: CEPAL a base de informaciones del Instituto de Fomento Economico, Proyecto de Recursos Hidraulicos y Electrificacion del S.C.I.F.E.

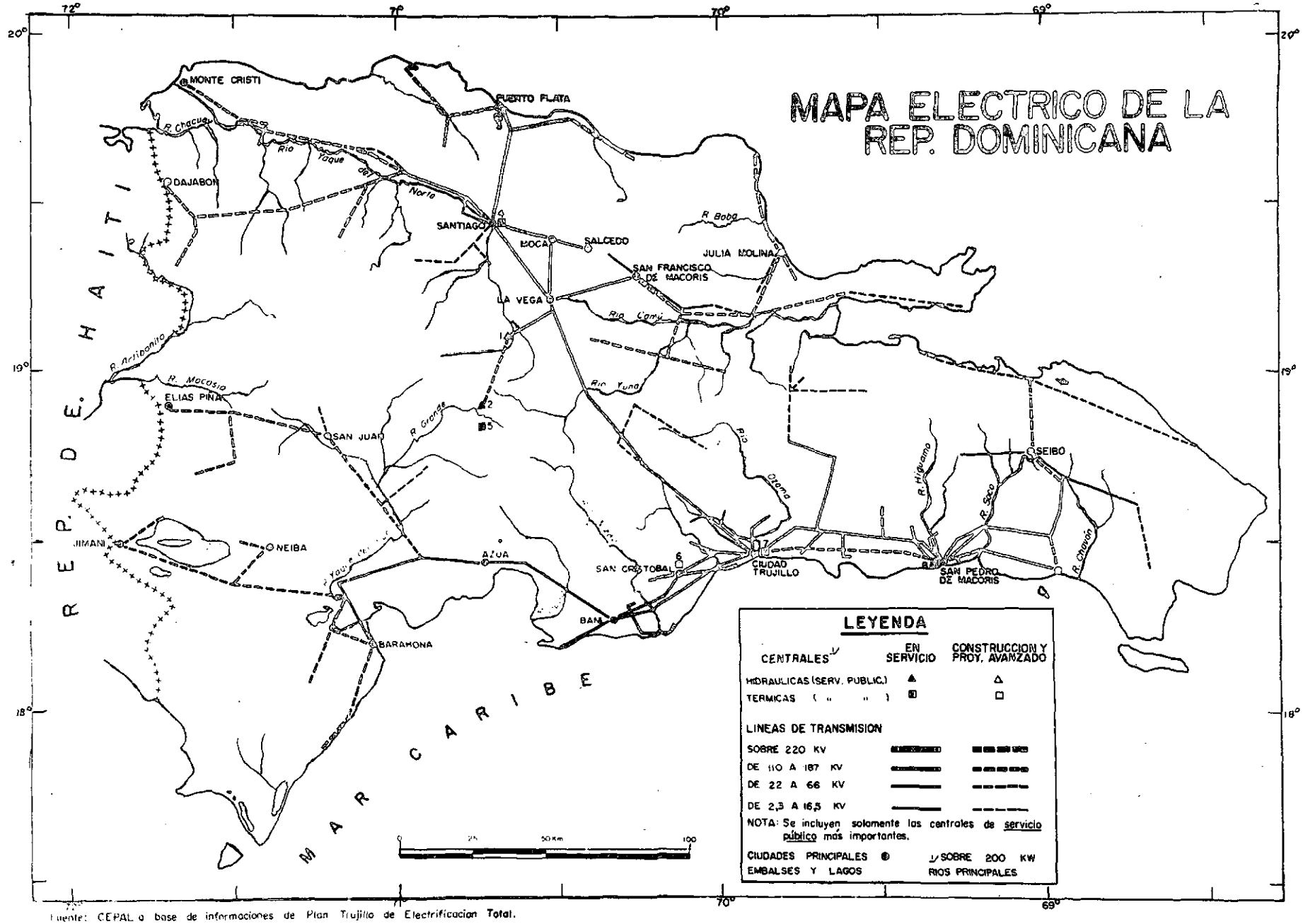


Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL o base de información directa de A.N.D.E.



Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.
Fuente: CEPAL a base de informaciones del Ministerio de Fomento y Obras Públicas Plan de Electrificación Nacional, Dirección de Ind. y Elec. y otros.

MAPA ELECTRICO DE LA REP. DOMINICANA



LEYENDA

CENTRALES ✓	EN SERVICIO	CONSTRUCCION Y PROY. AVANZADO
HIDRAULICAS (SERV. PUBLIC.)	▲	△
TERMICAS (" ")	■	□

LINEAS DE TRANSMISION

SOBRE 220 KV	▬▬▬
DE 110 A 187 KV	▬▬▬
DE 22 A 66 KV	———
DE 2,3 A 16,5 KV	———

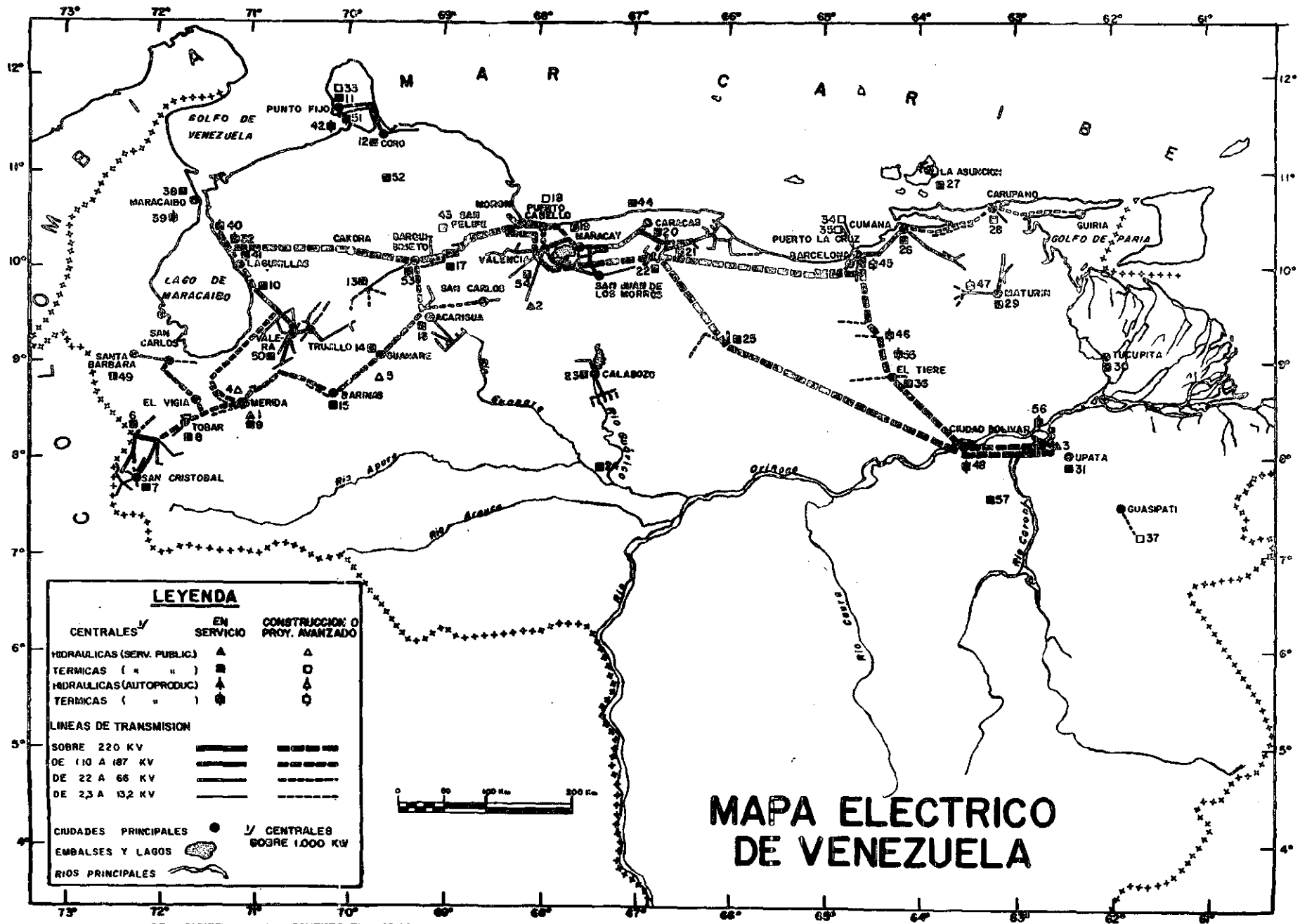
NOTA: Se incluyen solamente las centrales de servicio público más importantes.

CIUDADES PRINCIPALES ◉ ✓ SOBRE 200 KW

EMBALSES Y LAGOS RIOS PRINCIPALES

Fuente: CEPAL o base de informaciones de Plan Trujillo de Electrificacion Total.

Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.



FUENTE: C. A. DE ADMINISTRACION Y FOMENTO ELECTRICO

Los fronteras señalados en este mapa no implican que las Naciones Unidas las acepten o apoyen oficialmente.